NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Energy Conservation Performance Plan (Ten-Year)

KENNEDY SPACE CENTER

8/22/2017

Approval

Robert D Cabana

Robert D. Cabana
Director, Kennedy Space Center

22 Aug 17

Date

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Change Log

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* In accordance with NASA Procedural Requirements (NPR) 8570.1A, the Center Director's signature is required every four years (two revision cycles).				

TABLE OF CONTENTS

EXECUTIVE SUMMARY

PURPOSE

The purpose of this Energy Conservation Performance Plan (ECPP) is to document the historical progress and future actions necessary for the National Aeronautics and Space Administration (NASA), John F. Kennedy Space Center (KSC), to comply with the energy conservation, water conservation, renewable electric energy, clean energy, and other goals set forth in Federal regulatory requirements and NASA directives, while upholding and supporting KSC's overall mission effectiveness. Various Federal laws, Executive Orders (EOs), and mandates require NASA to reduce energy (electricity, natural gas, and other fuels) and water consumption, increase use of renewable electric energy and clean energy, and ensure energy and water resiliency and security. NASA Headquarters is turning to Field Centers and Component Facilities to do their part in meeting the requirements. The Agency has also tasked each of its Centers to identify, plan, and incorporate sufficient resources into their institutional and program budget submissions to meet Agency-specific targets and, if necessary, identify any funding or manpower gaps. The Energy and Water Management Program is intended to enhance the accomplishment of KSC's missions in a more efficient and sustainable manner as well as maximize value to the United States taxpayer.

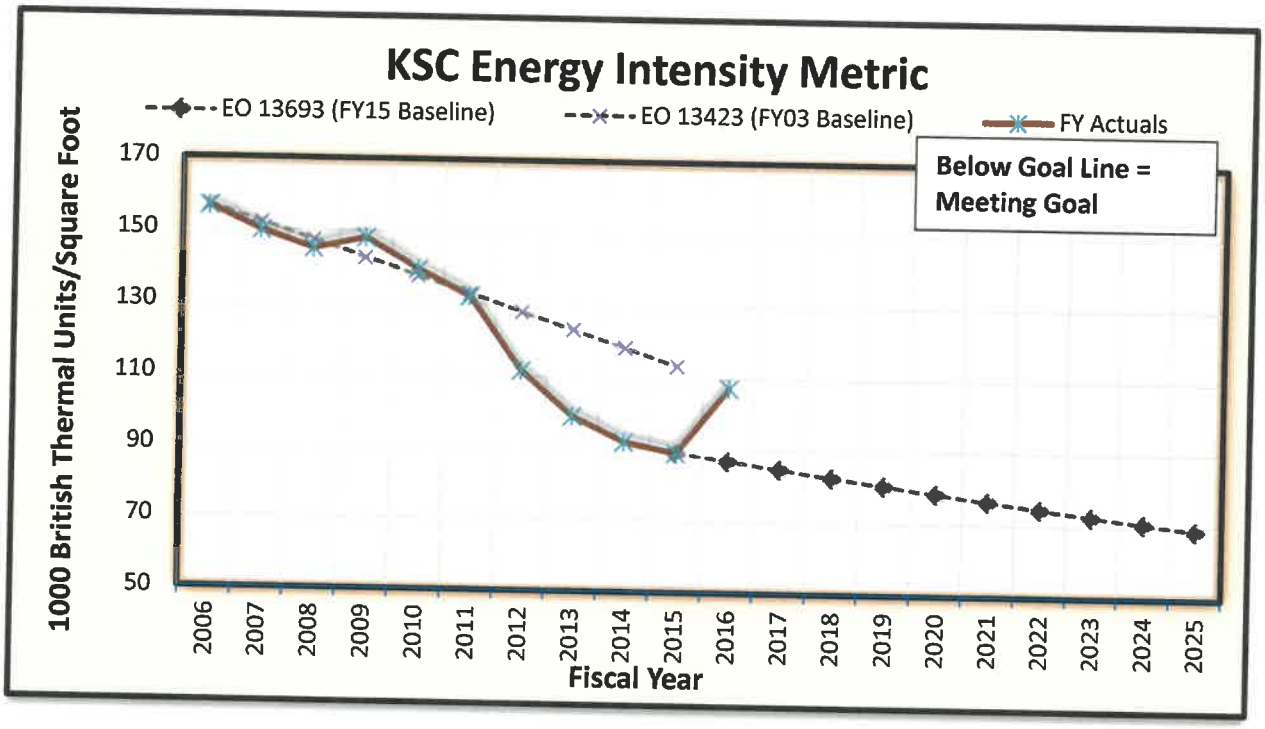
Located within a 140,000-acre national wildlife refuge in a subtropical coastal environment, and while continuing to expand its role as a multiuser spaceport, KSC faces a number of unique opportunities and challenges for improving its sustainability footprint. In addition to being the home of several NASA programs, the Center hosts commercial, state of Florida, and Federal entities with unique interests and drivers. All of these groups are directly affected by many of the energy and water strategies that KSC implements.

The Energy and Water Management Program at KSC is postured to ensure progress on all Federal sustainability mandates, with support from NASA Headquarters, KSC management, KSC forums like the Energy Working Group (EWG) and Water Working Group (WWG), our contractors, and the general work-force. Several management councils serve as a vehicle for setting KSC-specific environmental policy and objectives, obtaining management support, assessing progress, and sharing best practices.

The Center has developed this ten-year plan in a dynamic business climate where Agency programs and projects are undergoing significant change. This plan will continue to evolve with the times, while saving taxpayer dollars, reducing mission risks, conserving natural resources, and challenging the workforce to meet ever-increasing Federal energy and water goals. Due to NASA's vision and mission with regard to sustaining life on Earth and extending it elsewhere, environmental stewardship is inherent to NASA's objectives.

This ECPP should be reviewed annually and shall be updated every two years, at a minimum, and signed by the Center Director every four years.

ENERGY



- The goal for Fiscal Year (FY) 2015 was a 30 percent reduction in energy intensity from the FY 2003 baseline.
- In FY 2015, KSC showed a reduction of 50.92 percent and met the goal.
- In FY 2015, energy (electricity, natural gas, and other fuels) costs totaled approximately $14.3 million.
- EO 13693 requires a reduction of energy intensity (British thermal units per gross square foot [BTU/GSF]) in Goal Subject (GS) buildings of 25 percent by the end of FY 2025 from an FY 2015 baseline. That target may be achieved by either:
    a. 2.5 percent annually through the end of FY 2025, or
    b. 25 percent by the end of FY 2025.

The KSC FY 2015 baseline energy intensity is 162 million BTU (MMBTU)/GSF. The FY 2025 25 percent reduction target is 66.4 MMBTU/GSF.

RENEWABLE ELECTRIC ENERGY

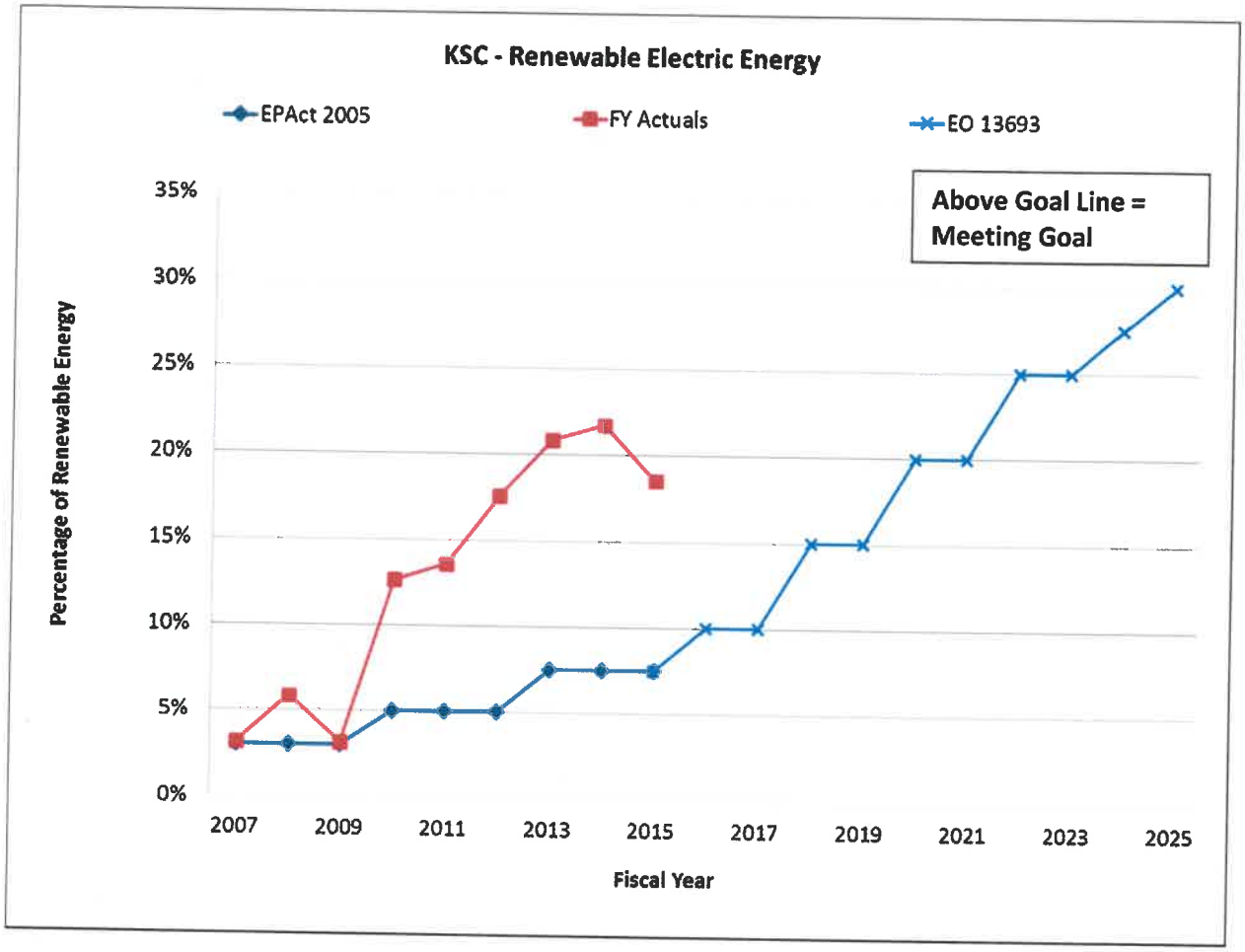
Although KSC does not have a regular line item in its budget for renewable energy projects, the Center has successfully begun tapping into its renewable energy potential through innovative means. In 2009

Florida Power & Light (FPL) built a 10-megawatt (MW) solar photovoltaic (PV) facility on KSC land to service North Merritt Island customers, and in return, FPL constructed and maintains a 1-MW solar PV facility that provides electricity to KSC. Both projects were completed at no cost to NASA via an Enhanced Use Lease (EUL) agreement. The EUL allows each facility to be expanded at a future date. A recent rule change by the Department of Energy (DOE) has significantly benefited organizations such as KSC by allowing credit for renewable energy generated on KSC property regardless of who consumes it. As a result, the Center can now take credit for electricity production at both the 1-MW and 10-MW PV facilities, instead of just the 1-MW plant under the prior rules.

Other sources of renewable energy at KSC include the Propellants North Facility (roof-mounted and awning-mounted solar panels), a solar collector heating water at the Film Storage Building, solar panels powering the weigh station at KSC's landfill, and a geothermal heat pump servicing the Ordnance Operations Facility.

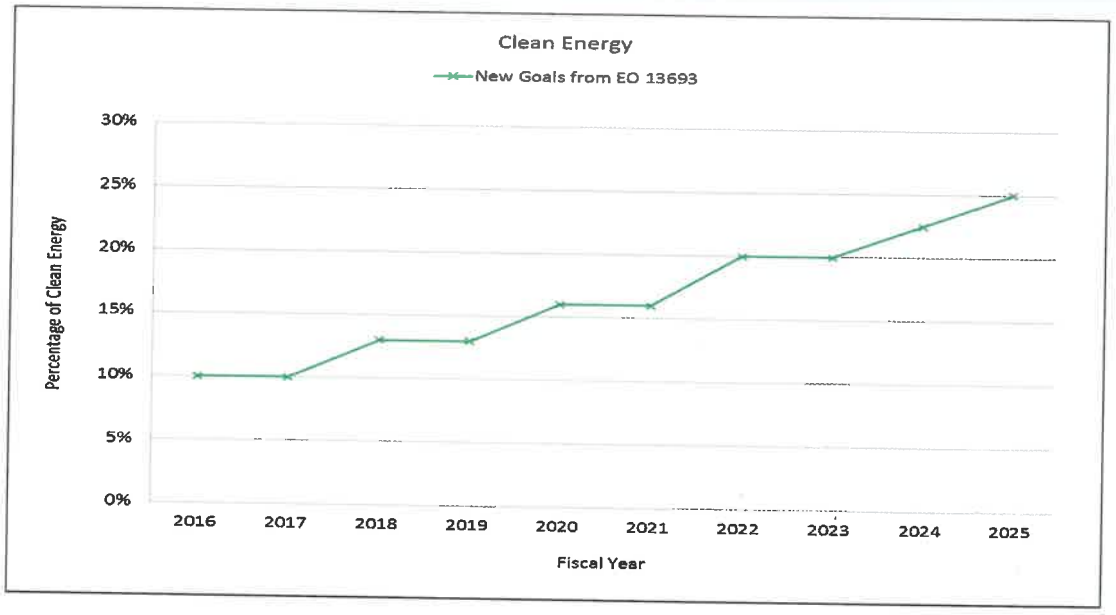
In FY 2015, a new $6.8 million Construction and Environmental Compliance and Restoration (CECR) contract was awarded to expand our existing 1-MW facility by another 2 MW of PV energy. This expansion will be independent of FPL, but located adjacent to the 1-MW facility. The expansion is expected to provide KSC with enough renewable energy to enable Phase 1 of KSC's Central Campus construction project to be net-zero for energy in accordance with the EO 13693 goal. To further this pursuit, in June of 2016, KSC issued a public Notice of Availability, seeking land use proposals involving renewable energy, among other objectives.

The Center intends to complement onsite renewable energy generation with the purchase of enough Renewable Energy Certificates (RECs) to exceed annual goals by at least a 10 percent margin. RECs are tradable, nontangible energy commodities in the United States that represent proof that 1 megawatt-hour (MWh) of electricity was generated from an eligible renewable energy resource (renewable electricity) and was fed into the shared system of power lines that transport energy. KSC will then have a modest buffer built into the goal should there be an unforeseen generation drop or consumption increase.



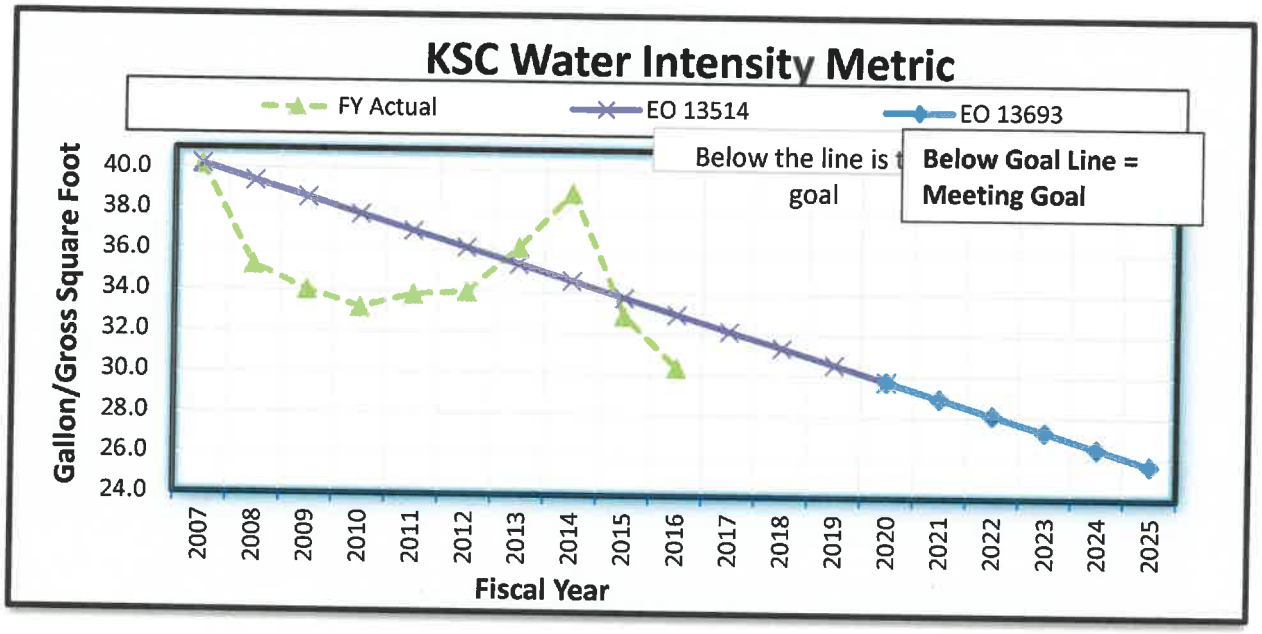
- The goal for FY 2015 was to have 10 percent of energy from renewable sources as measured according to standard Federal guidelines.
- In FY 2015, 18.5 percent of KSC's energy consumption came from renewable sources, including via the purchase of RECs. Thus, KSC exceeded the goal.
- In FY 2015, renewable electric energy costs were in the form of RECs, totaling approximately $3,055. The same amount was purchased for FY 2016 as well.
- The goal for FY 2016 is also for 10 percent renewable electric energy consumption. EO 13693 set new renewable electric energy goals extending through FY 2025.

CLEAN ENERGY



- EO 13693 added clean energy goals for the first time, with a goal for FY 2016 of 10 percent clean energy consumption. Clean energy is a combination of renewable electric energy and alternative energy. Clean energy does not leave behind harmful by-products, such as pollution or greenhouse gases.
- The KSC Energy and Water Management Program continues to focus on renewable energy actions.

WATER



- The goal for FY 2015 was a 16 percent reduction in water intensity from the FY 2007 baseline.
- In FY 2015, KSC showed a reduction of 18.08 percent and met the goal.
- In FY 2015, the reduced water consumption for NASA KSC and its contractors (excluding consumption by Department of Defense [DOD], state, and commercial partners on the Center) achieved an annual cost savings of approximately $263,720 compared to FY 2007.
- The goal for FY 2016 is an 18 percent reduction in water intensity from the FY 2007 baseline. EO 13693 extended goals set forth in previous regulations through FY 2025. FY 2007 remains the baseline year for these extended goals.
- The KSC Energy and Water Management Program completed Phases 3 and 4 of a large water and wastewater infrastructure revitalization project in 2015. A design is in place for Phases 5 and 6 of this project, with the intent of further working toward these goals. A request to fund Phases 5 and 6 is in the President's FY 2017 budget proposal to Congress.

RESOURCES

NASA HEADQUARTERS FUNDING

In recent years the Center has received CECR funding from NASA Headquarters for specific conservation and load-shifting projects. This includes the aforementioned expansion of KSC's PV farm in the Industrial

Area, a light-emitting diode (LED) lighting upgrade/retrofit project for a number of buildings, and construction of a Thermal Energy Storage (TES) system.

In FY 2015 the Center received $800 thousand from the Agency for an EUL project that will upgrade the Heating, Ventilation, and Air Conditioning (HVAC) system in Building M7-0505.

CENTER MANAGEMENT AND OPERATION FUNDING

The Center may retain energy and water savings in accordance with the National Energy Conservation Policy Act (NECPA) for energy efficiency projects.

> 42 U.S.C. 8256(e) RETENTION OF ENERGY AND WATER SAVINGS An agency may retain any funds appropriated to that agency for energy expenditures, water expenditures, or wastewater treatment expenditures, at buildings subject to the requirements of section 8253(a) and (b) of that title, that are not made because of energy savings or water savings. Except as otherwise provided by law, such funds may be used only for energy efficiency, water conservation, or unconventional and renewable energy resources projects. Such projects shall be subject to the requirements of section 3307 of title 40.

In addition, the EUL program was recently transferred to the KSC Energy and Water Program at KSC and provides a modest funding source that can be used for energy and water saving projects.

PERFORMANCE CONTRACTING

The primary KSC alternative financing method has traditionally been the Utility Energy Service Contract (UESC) mechanism. Since 1998, numerous UESC projects improving KSC's energy and water efficiency were completed. Many were completed with FPL and were successful in lowering utility costs, with a financial payback of less than eight years. Southern Company started its first UESC project with KSC in 2012. Table 1 provides a list of the utility performance contracts on Center, respective project value, year initially contracted, and the corresponding contractor.

Project Name	Project Value	Year	UESC
Lighting Upgrades - Various Facilities	$460,509	1998	FPL
Lighting Upgrades - Various Facilities	$68,285	1998	FPL
C5 Emergency Power Plant	$6,838,707	1998	FPL
Thermal Energy Storage Feasibility Study	$15,000	1999	FPL
Launch Equipment Shop Lighting	$26,971	2000	FPL
Communications Distribution and Switching Center Load Control	$4,500	2000	FPL
Shuttle Area Phase 1 – HVAC, Lighting Upgrades, and Compressed Air Upgrades	$3,177,532	2001	FPL
Shuttle Area Phase 2 – HVAC, Boilers, Lighting and Load Shedding Upgrades	$3,696,068	2005	FPL
Modular Boiler Project	$4,894,546	2006	FPL
Mechanical Upgrades	$2,689,597	2012	FPL
Lighting Upgrades - Various Facilities	$776,000	2012	Southern Company
Lighting Upgrades - Various Facilities	$704,000	2013	FPL

Table 1 - Utility Performance Contracts

The Center will continue to pursue alternative financing through UESCs. As the above table shows, one of the largest UESC projects included decentralizing portions of the Central Heat Plant (modular boiler project). The Center found that even insulated piping exhibited substantial heat losses. Eliminating transmission lines and positioning modular boilers closer to their point of use have helped alleviate the issue. Overall, these projects have collectively provided substantial energy and cost savings.

Another candidate resource is an Energy Savings Performance Contract (ESPC) called ENABLE (not an acronym). ENABLE is intended to provide a standardized and streamlined procurement process for Federal projects that have an estimated cost of up to $5 million. To be eligible, projects must install targeted energy conservation measures (ECM) in six months or less. While there are no specific facility size restrictions, the ESPC ENABLE is well-suited to meet the needs of many Federal facilities with less than 200,000 square feet (SF) of space.

OTHER FUNDING

The Center has benefited through direct appropriations for Construction of Facilities (CoF) projects too. Phases 3 and 4 of a large, multiyear water conservation project were just completed in FY 2015. So far, the KSC Water and Wastewater Revitalization Project has resulted in significant water savings, environmental benefits, and continued critical support of crewed and uncrewed launches at KSC. Many of KSC's systems were refurbished and replaced to improve overall water quality, reduce overall water usage, extend infrastructure life, and replace asbestos cement piping.

The President's FY 2017 budget proposal to Congress includes additional money for Phases 5 and 6 of this same revitalization effort.

The TES project also provided KSC with a utility rebate several orders of magnitude larger than any other rebate received to date.

Occasionally, one of the NASA programs located at KSC will also fund conservation projects. For example, from FY 2013 through FY 2017, the Ground Systems Development and Operations (GSDO) Program funded miscellaneous mechanical and lighting upgrades across KSC that total $4.6 million.

STAFFING

At KSC, in support of EO 13693 objectives, civil servant labor amounts to approximately 5.3 full-time equivalents (FTEs), and contractor labor support includes approximately 4.5 workyear equivalents (WYEs). The WYE number represents only an approximation because in FY 2016 the contractor performing the work had a firm-fixed-price contract; support was not tracked by WYE, but by output. The civil servant and contractor support is paid for by the Center Management and Operations (CMO) budget. Contract baseline work includes energy compliance activities and facility comprehensive evaluations (FCE).

The Center does not anticipate any substantial changes to these civil servant and contractor labor numbers. The current 2016 costs of this support are approximately $693,000 for civil servant and $545,000 for contractor.

OTHER RESOURCES

There are several other resources that KSC may pursue. Federal grants are currently being reviewed to determine KSC's eligibility and grant applicability to KSC projects in need of funding. Because of the limited timeframe during which a particular grant might be available, the Center has begun to more closely monitor for these opportunities.

Additional CMO program support comes in the form of low-cost/no-cost ECMs, such as changes to maintenance procedures and facility setpoint changes. The Center also has technical teams, organized by discipline, that conduct independent reviews of conservation measures that come from facility condition assessments. Their labor is paid directly from the CMO budget.

UTILITY CONTRACTS AND RATES

Natural gas is a commodity that KSC procures under the Defense Logistics Agency (DLA) energy provision. DLA compares the commodity cost if purchased through the local gas utility, Florida City Gas (FCG), and others to determine the best option for KSC. The commodity is market priced on a monthly basis. The Center has benefited from participation in the DLA Natural Gas Program.

Charges for natural gas are based on tariffs per meter (as opposed to a single charge to the Center). The applicable rate is assigned to each meter based on the volume that is passed through that meter annually. The tariffs themselves change every year. KSC programs budget for natural gas in their operating plans and through the Planning, Programming, Budgeting, and Execution (PPBE) process using forecasted consumption and predicted rates.

Water and electricity are sourced solely through the local utilities that service KSC. Electric rates are regulated through the Florida Public Service Commission (FPSC). The FPSC recently approved a 17 perceny rate increase to be phased in from FY17 through FY20.

COMPREHENSIVE EVALUATIONS

KSC is progressing toward its facility evaluation requirements. Approximately 25 percent of GS facility square footage will be evaluated each fiscal year with the intent of performing an FCE on 100 percent of such facilities every four years. KSC has a plan to ensure compliance with the comprehensive evaluation goal by leveraging onsite contractor support. In April of 2016, KSC completed its most recent four-year cycle and has begun audits that will count toward the first year of the new cycle. A representative annual list of GS facilities and their FCE schedule is available in Appendix B.

ENERGY CONSERVATION PERFORMANCE PLAN

PURPOSE

The purpose of this ECPP is to document the historical progress and future actions necessary for NASA KSC to comply with the energy conservation, water conservation, renewable electric energy, clean energy, and other energy and water-related sustainability goals set forth in Federal regulatory requirements and NASA directives, while upholding KSC's overall mission effectiveness. Various Federal laws, EOs, and mandates require NASA to reduce energy and water consumption, increase use of renewable electric energy and clean energy, and take steps to help ensure energy and water security within the Agency. NASA Headquarters is working with individual Centers and Component Facilities toward meeting the requirements. The KSC Energy and Water Management Program is intended to enhance the accomplishment of KSC's missions in a more efficient and sustainable manner and maximize value to the United States taxpayer.

This ECPP should be reviewed annually and shall be updated every two years, at a minimum, and signed by the Center Director every four years.

APPLICABILITY

Energy and water management, conservation, and consumption, as referred to in this plan, are applicable only to the energy and water used by NASA KSC, associated Component Facilities, and NASA support contractors. Each resident agency is individually responsible and accountable through its respective headquarters for the energy and water it consumes. The impact of Federal Government residents of KSC facilities is considered only to the extent that their requirements are factored into the plan for modifying and/or replacing existing energy and water systems within the facilities they occupy and the sitewide utilities that support them. Facilities responsible for such functions are referred to as GS facilities. Commercial, state, and DOD partners also reside on KSC property, but are generally not in GS facilities, and therefore their consumption is not counted toward KSC metrics reported to NASA Headquarters.

AUTHORITY

- National Energy Conservation Policy Act, as amended, 42 United States Code (U.S.C.) Chapter 91
- EO 13693, Planning for Federal Sustainability in the Next Decade, 80 Federal Register 57, March 25, 2015
- Energy Policy Act of 2005 (EPAct 2005)
- Energy Independence and Security Act of 2007 (EISA 2007)
- Preparing the United States for the Impacts of Climate Change, EO 13653, 78 Federal Register 66819, November 6, 2013 (Amended by EO 13693)
- Energy Efficiency Standards for the Design and Construction of New Federal Commercial and Multi-Family High-Rise Residential Buildings, 10 Code of Federal Regulations (CFR) Part 433

- Energy Code for New Federal Commercial and Multi-Family High Rise Residential Buildings, 10 CFR Part 434
- Energy Efficiency Standards for New Federal Low-Rise Residential Buildings, 10 CFR Part 435
- Federal Energy Management and Planning Programs, 10 CFR Part 436

APPLICABLE DOCUMENTS

- NASA Policy Directive (NPD) 8500.1, NASA Environmental Management
- NPR 1040.1, NASA Continuity of Operations (COOP) Planning Procedural Requirements
- NPR 8530.1, NASA Sustainable Acquisition
- NPR 8553.1, NASA Environmental Management System
- NPR 8570.1, NASA Energy Management Program
- NPR 8820.2, Facility Project Requirements (FPR)
- NPR 2810.1, Security of Information Technology
- Kennedy NASA Procedural Requirements (KNPR) 8715.2, Comprehensive Emergency Management Plan
- KNPR 8500.1, Kennedy Space Center Environmental Requirements
- KNPR 8553.1, NASA Kennedy Space Center Sustainable Environment Management System (SEMS)
- Kennedy Documented Procedure (KDP)-KSC-P-3006, Kennedy Space Center Tropical Storm and Hurricane Preparation
- KDP-KSC-P-3007, Kennedy Space Center Damage Assessment and Recovery
- KDP-KSC-P-3012, Kennedy Space Center Loss of Utilities
- KDP-P-3701, Continuity of Operations Planning (COOP) Emergency Funding
- Guiding Principles for Sustainable Federal Buildings
- National Institute of Standards and Technology (NIST) SP 800-82, Guide to Industrial Control Systems (ICS) Security

FACILITY DESCRIPTION

KSC consists of approximately 140,000 acres of land located in Merritt Island on the central east coast of Florida. NASA began acquisition of the land in 1962, and the current book cost (as of March 31, 2017) is $73,672,344. The Center's assets were built from the 1960s to the most recent new Headquarters Building, the cornerstone of KSC's Central Campus project, which will be completed in 2018. As of March 31, 2017, KSC had approximately 7.8 million SF and a book cost of $1,029,412,529 and other structures with approximately 18 million SF and a book cost of $808,710,796. KSC buildings include administrative spaces, shops, warehouses, laboratories, spacecraft and launch vehicle processing facilities, and so on, and the "other structures" asset category includes airfield pavements, roads and bridges, utility systems, parking areas, and more.

The Center also has facilities located on the Cape Canaveral Air Force Station (CCAFS). Those assets include 248,740 SF and a book cost of $33,048,837, and other structures with 255,851 SF and a book cost of $19,474,198.

NASA FACILITY DEFINITIONS

The EPAct of 2005 offers exclusions from regulatory energy performance requirements for some Federal buildings if they meet certain exclusion criteria. The exclusions are further established in the U.S. DOE Federal Energy Management Program (FEMP) "Guidelines Establishing Criteria for Excluding Buildings."

- **Goal Excluded (GE)** - GE facilities are described in the U.S. DOE's FEMP, January 27, 2006, published "Guidelines Establishing Criteria for Excluding Buildings" from the Energy Performance Requirements of Section 543 of the NECPA, as Amended by the EPAct of 2005. These facilities are excluded from energy performance requirements.
- **Reimbursable (RE)** – Facilities owned by the site but used by other organizations. These facilities are excluded from energy performance requirements.
- **Goal Subject (GS)** - All buildings or complexes not categorized as GE or RE.

ORGANIZATION

LEAD AND SUPPORTING ORGANIZATIONS

The lead KSC organization responsible for coordinating energy and water conservation efforts is the Environmental Management Branch in the Spaceport Integration and Services directorate. The Branch interfaces with all KSC organizations, several contractor organizations, and each program on Center. All energy and water system users share responsibility for conservation, and because KSC's programs are responsible for paying their own utility bills, the incentive for conservation lies within the programs and their own supporting organizations.

ENERGY AND WATER CONSERVATION TEAMS

The KSC EWG and WWG meet the NPR 8570.1 requirement for energy and water efficiency teams. Team members are drawn from a wide cross section of relevant Center organizations. Committee membership is composed of representatives from:

- Medical and Environmental Services Division (SI)
- Exploration Research and Technology Programs
- Center Services Division (SI)
- Spaceport Management and Integration Division (SI)
- Office of the Chief Counsel
- Procurement
- Engineering, including CoF
- Office of the Chief Financial Officer
- Center Planning and Development
- Information Technology and Communications Services
- Ground Systems Development and Operations (GSDO) Program
- Launch Services Program
- Program and institutional support contractors

The EWG meets monthly and the WWG meets bimonthly to discuss issues, develop strategies, and prepare responses to Center and external requests and requirements. The charter for both teams says the following:

> "Ensure that Kennedy Space Center (KSC) makes continual progress towards compliance with Federal energy and water efficiency mandates to reduce energy and water costs. Provide a forum to develop policies and plans regarding energy and water matters, report progress and accomplishments, increase awareness, advocate and pursue initiatives and technology applications, forecast consumption and cost, and foster consistency across all Center elements."

TRAINING

Each KSC organization is responsible for the efficient use of its training funds. In order to meet existing energy and water mandates, the KSC energy and water working groups receive frequent announcements from the DOE FEMP, the Association of Energy Engineers, and the U.S. Green Building Council, which are then communicated to the KSC energy and water community. All EWG and WWG members are

encouraged to pursue training opportunities. The EWG and WWG emphasize the importance of training in key areas, including, but not limited to:

- Performance contracting
- Buying energy-efficient products
- Life cycle costing
- Energy and water resource management
- Operations and maintenance (O&M) management

Seminars sponsored by the DOE and other industry leaders are also used for applicable training. The Energy and Water Manager encourages appropriate team members to become Certified Energy Managers (CEMs).

Energy and Water Managers, along with O&M personnel at KSC, have held titles such as Leadership in Energy and Environmental Design (LEED) Certified and CEM. Personnel attend energy conferences, annual Green Build events, and various other energy- and water-related training activities. When offered locally, O&M staff attend NASA's Academy of Program/Project and Engineering Leadership training, such as "Sustainable Buildings."

COMMUNICATION

There are several established avenues to raise issues and share information with KSC senior managers, including, but not limited to, KSC Center Management Council (KCMC) meetings, Sustainable Environment Management System (SEMS) Steering Committee quarterlies, KSC Senior Staff weekly meetings, weekly organization management staff meetings, monthly EWG and bimonthly WWG meetings, and Quarterly Project Management Reviews. The SI Director, who is also the Center's Chief Sustainability Officer, is very supportive of energy and water conservation and has taken an active role in identifying opportunities for improvement across all of KSC. As an example of senior management involvement, the SI Director has been a continuous, strong advocate for the Central Campus initiative, and the decision to fund Phase 1 of this project was the result of numerous analyses and discussions that required concurrence from the Center Director. The first phase of Central Campus includes a new KSC Data Center and new Headquarters Building which will replace the Central Instrumentation Facility and existing Headquarters Building. The Data Center is a LEED Silver certified facility and the Headquarters Building is projected to be both LEED Gold certified and achieve net-zero status for energy.

AWARENESS AND OUTREACH

Energy and water conservation awareness is accomplished through a variety of venues. Information can be found on the KSC Energy and Water Web site, a subsite of the Environmental Management Web site. The Center publishes an annual Sustainability Report and a Five-Year Sustainability Plan. The electronic *KSC Daily News* reminds employees of common sense energy and water savings practices during day-to-day operations, with similar notices prior to all Federal holidays. A popular annual competition is the "Guess the KSC Electric Bill Contest." Employees are encouraged to guess the energy and water bill for a specific month and the person with the closest guess receives an award. Additional energy/water-related awards are the Catch an Environmentalist Award and the Sustainable Environment Awareness Award.

Figure 1: KSC Energy Logo

ENERGY AWARENESS DAY

KSC holds an Energy Awareness Day as part of October's Energy Awareness Month. Activities include providing information on energy conservation published in KSC bulletins and major facility lobbies, prizes for events such as "Guess the KSC Electric Bill," and information and energy-related promotional items provided by vendors and local utilities. The primary objective is to expose employees to, and increase awareness of, our everyday mission of conserving energy. Providing incentives, such as promotional items, helps to further spark energy awareness at KSC. Figure 2 is an example of an awareness booth providing informational pamphlets on energy conservation projects and programs.

Figure 2 – Energy Day Awareness

EARTH DAY

In support of Earth Day 2016, KSC and the KSC Visitor Complex co-hosted an Earth Day event at both locations. Activities showcased sustainability themes, including energy-saving solutions and renewable energy. More than a dozen electric cars were on display, with test drives available for several cars. Master gardeners and pollinator specialists answered questions and offered tips for Florida Friendly Landscaping™ and water conservation. Wildlife and natural conservation specialists discussed methods to safeguard wildlife, preserve natural resources, and protect Florida waters. Approximately 50 exhibitors from around the United States participated.

The energy and water teams always encourage members and Center utility providers to set up energy and water booths to display recent achievements and new products and to talk with any guests about the Center's current energy and water conservation efforts. Earth Day events at KSC are intended to educate the workforce on how to be better stewards of the environment, while vendors promote commercial and residential green practices, sustainable products, and services. Given the local community and KSC's dedication as a whole, typically hundreds attend each year.

ARTICLES

Sustainability tips pertaining to energy and water are published in the *KSC Daily News* and often address conservation benefits that go beyond cost savings. They often include links that provide the reader with a more in-depth perspective. Sample excerpts of actual tips include:

- Make a green New Year's Resolution! An easy sustainable resolution this year might involve committing to turning off Government electronic devices overnight and on weekends to help reduce energy consumption. Or consider starting a weekly bring-your-lunch day with your coworkers to reduce food runs, fuel used, CO2 emissions, and waste generation. This also promotes healthy eating. No matter what your resolution is this year, make one that helps KSC meet NASA's sustainability goals, too. Everyone doing their small part can make a big difference!

- Did you know that the average U.S. household uses more water outdoors for landscape irrigation than most American homes use for showering and washing clothes combined? It's easy to reduce your outdoor water footprint and still have a beautiful, healthy, low-maintenance lawn. For more information visit the Environmental Protection Agency Water Sense Web site at https://www.epa.gov/watersense/outdoor/.

In addition, KSC also publishes a Five-Year Sustainability Plan that recognizes that the best sustainable solutions use an interdisciplinary, collaborative approach spanning civil servant and contractor personnel from across the Center. This approach relies on the participation of all employees to develop and implement sustainability endeavors connected with the following ten goals:

- Reduce greenhouse gas emissions.
- Design, build, and maintain sustainable buildings, facilities, and infrastructure.
- Leverage clean and renewable energy.
- Increase water conservation.
- Improve fleet and vehicle efficiency and management.
- Purchase sustainable products and services.
- Minimize waste and prevent pollution.
- Implement performance contracts for Federal buildings.
- Manage electronic equipment and data centers responsibly.
- Pursue climate change resilience.

WEB PAGE

The KSC energy and water management Web page begins with an overview describing the Center's physical size and other characteristics, such as incoming facility energy ratios among electricity, natural gas, fuel oil, and propane sources. It references consumption and cost statistics, energy and water mandates, working groups, conservation goals, reporting tools, Center initiatives, and recent Center accomplishments. There is also a list of energy-related links pertaining to work/home energy saving information and educational Web sites.

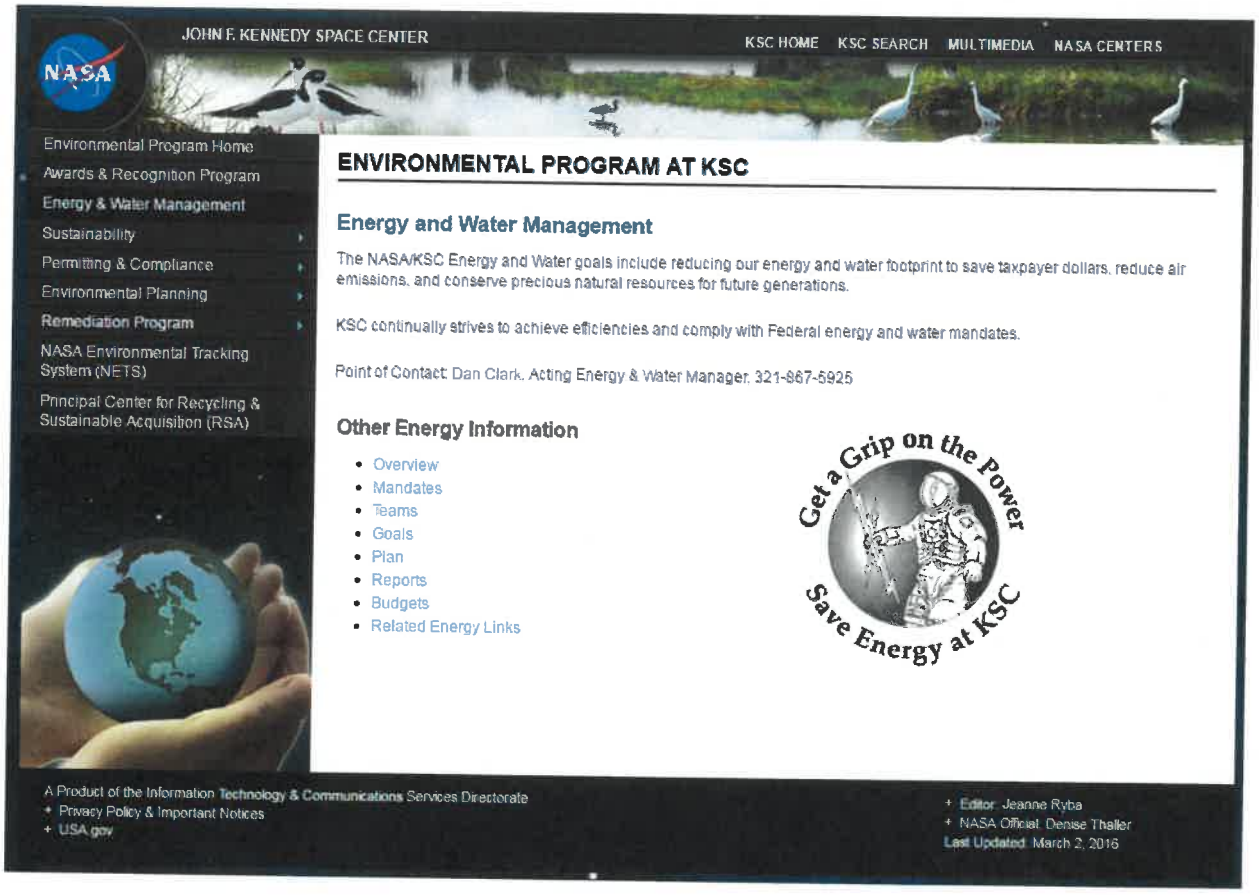


Figure 3 – Energy and Water Program Web site

OTHER

For several years KSC has been a participant in the Green Buildings competition; competed for NASA's Blue Marble, GreenGov, and FEMP awards; and used Portfolio Manager tools such as Battle of the Buildings. Notifying employees about these opportunities and activities is accomplished through several means, including e-mail blasts, displaying posters in facility entrances, announcements at meetings, and including Web links for more information in the *KSC Daily News*.

Coordinating energy and water conservation input with KSC's master planning group has improved employee awareness and helped to unify the efforts. A snapshot of the Master Planning Web site can be seen below.

In addition, a sustainability tip is provided by a different directorate at the beginning of each KCMC meeting.

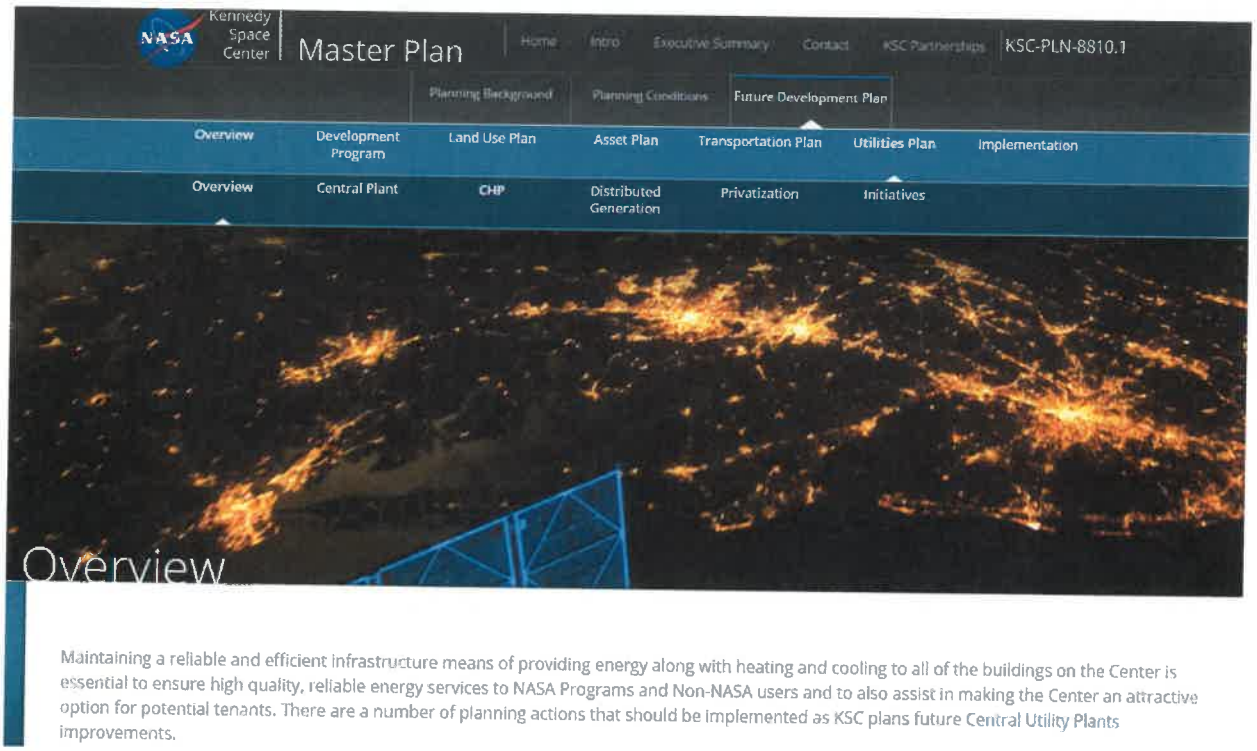


Figure 4 – Master Planning Web Site Utilities Section

ENVIRONMENTAL MANAGEMENT SYSTEM

KSC follows the process of NPR 8553.1 to determine scope and priority aspects. This is captured in KNPR 8553.1. In the identification of priority aspects, the KSC SEMS Steering Committee, KSC SEMS Goal Points of Contact/Champions, and Crosscutting and Tactical Support Teams review normal, abnormal, and emergency situations and the actual and potential environmental impacts and/or benefits from those activities. The review includes looking at factors pertaining to energy and water. Each aspect is graded and ranked against the others using predetermined criteria. From this ranking, the Center's highest SEMS priorities are identified and a corresponding priority management plan (PMP) is created for each one. The PMP outlines unique task elements, performance measures to monitor progress, and resources necessary to achieve success.

ENERGY

For FY 2016, energy efficiency was identified as one of two KSC high-priority aspects. It was given this rating because EO 13693 reset the energy intensity baseline year to 2015, while still requiring annual intensity reductions of 2.5 percent. Previously, the Center had reduced its energy intensity by a remarkable 51 percent from 2003 through 2015, well ahead of the goal to reduce by 30 percent over the same period. It will be very challenging to continue meeting the 2.5 percent annual reduction target with each successive year because the Center has already made such tremendous progress. By making it a

high priority, energy intensity will get more visibility by senior KSC management and will have the necessary management controls implemented.

To help achieve Center energy efficiency targets, the Center has identified several ongoing objectives and tasks. The primary objective and associated target is to first reduce energy intensity by 2.5 percent annually. KSC is pursuing this by identifying ECMs, generating proposals for various funding calls, keeping KSC organizations participating in monthly EWG meetings, and promoting energy awareness directed to the KSC workforce. A primary source for ECMs comes from performing FCEs.

RENEWABLE ELECTRIC ENERGY AND CLEAN ENERGY

The KSC SEMS currently rates renewable electric energy and clean energy as a high priority within the energy efficiency environmental aspect, in accordance with NPR 8553.1B. However, as a subtask under energy efficiency, KSC has identified the following objectives and associated targets: First, the Center will obtain at least 10 percent of its electricity from renewable energy sources. So far, KSC is obtaining 18.5 percent of its electricity from renewable sources. Second, it is designing sustainable and energy-efficient facilities. Phase 1 of the new Central Campus facility is expected to be net-zero for energy primarily due to a projected 1.5-MW expansion of KSC's existing solar farm. Third, the Center is seeking to incorporate combined heat and power (CHP) systems into KSC's infrastructure. So far though, no KSC facilities have been identified as ideal candidates for CHP applications. Lastly, Center personnel are evaluating wind power candidates. Harnessing wind power at KSC is challenged by a long-standing position of Merritt Island National Wildlife Refuge managers that wind power is not compatible with the objectives of a wildlife refuge. Bird and bat kills, as well as the impacts on wildlife habitat from vibrations associated with traditional windmills, are cited as concerns. However, recent technological advances designed to address those concerns and very innovative approaches such as bladeless wind turbines are behind KSC revisiting the option for wind power. Should a cost-effective, environmentally compatible solution be found, KSC has suitable deployment sites near existing power distribution infrastructure.

WATER

The KSC SEMS does not currently rate water conservation as a high priority in accordance with NPR 8553.1B. For FY 2016 water conservation was given a medium priority as ranked among 22 other beneficial environmental management impacts. Having medium priority means that the Center-wide team providing the rankings collectively believes appropriate controls, tracking, and visibility are already in place at KSC. Water conservation therefore does not need additional intervention by senior KSC managers for this fiscal year.

As mentioned elsewhere in this document, over the last several years KSC has embarked on large, multiyear water and wastewater infrastructure upgrade projects that have considerably helped with the Center's water conservation efforts. Even with much of KSC's plumbing now rightsized to meet anticipated needs, there are still opportunities for improvement. One challenge in continuing water infrastructure improvements is the relatively low cost of water in Florida. This makes the payback time

on water projects typically decades long, requiring pretty strong and diverse arguments to justify funding the projects.

KSC's water system is considered a consecutive public water system. The Center receives treated water from the City of Cocoa. Due to the age of the water as it enters KSC, the vast expanse of KSC's water system, and the Center's relatively limited usage, it is a challenge to maintain water quality. KSC often flushes water at the far extents of the system to maintain water quality. Efforts to conserve water at KSC can be in conflict with maintaining water quality. Although the water system improvements to date have significantly reduced the required flushing and therefore water consumption, further improvements within the O&M of the water system and coordination with the City of Cocoa will be necessary to fully realize future water conservation efforts.

ENERGY

LONG-TERM GOALS

EO 13693 requires a reduction of energy intensity (BTU/GSF) in GS buildings of 25 percent by the end of FY 2025 from an FY 2015 baseline. That target may be achieved by either:

- 2.5 percent annually through the end of FY 2025, or
- 25 percent by the end of FY 2025.

The KSC FY 2015 baseline energy intensity is 162 MMBTU/GSF. The FY 2025 25 percent reduction target is 66.4 MMBTU/GSF.

ENERGY DEMAND

Energy demand is the energy required to operate a facility. For KSC, the majority of energy consumed by its buildings is electricity. The remainder comes mainly from natural gas, renewable energy, and miscellaneous fuels. Awareness of Center energy demand is important. Understanding energy demand allows for estimating annual budget (utility costs), negotiating utility contracts, and tracking base demand, peak demand, and any reductions in demand due to projects, building optimization, or other Energy and Water Management Program activities. Monthly peak demand tends to shadow major KSC operations.

Electrical demand is the amount of electricity that is required at a given point in time. At KSC, the demand is a snapshot in time of the electrical power use. The maximum power use for each month is recorded. Awareness of the electrical demand is important to trend and document for estimating utility cost and infrastructure planning. Similar to the total energy consumption over time, the electrical demand increases approximately 20 percent during the summer months, as identified in Figure 6.

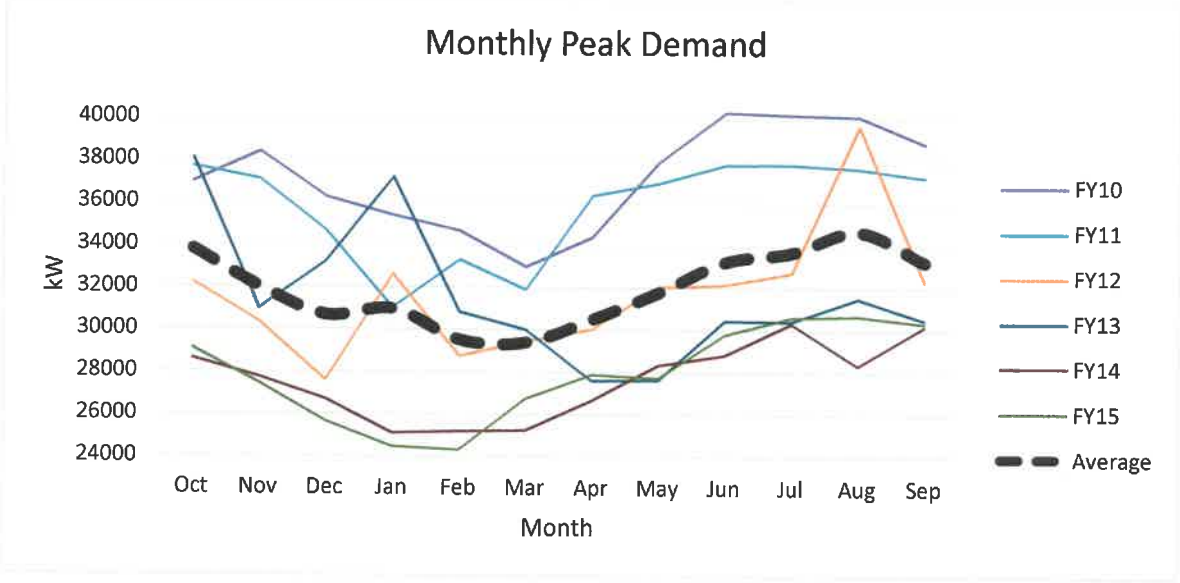


Figure 5 - KSC Monthly Electrical Demand

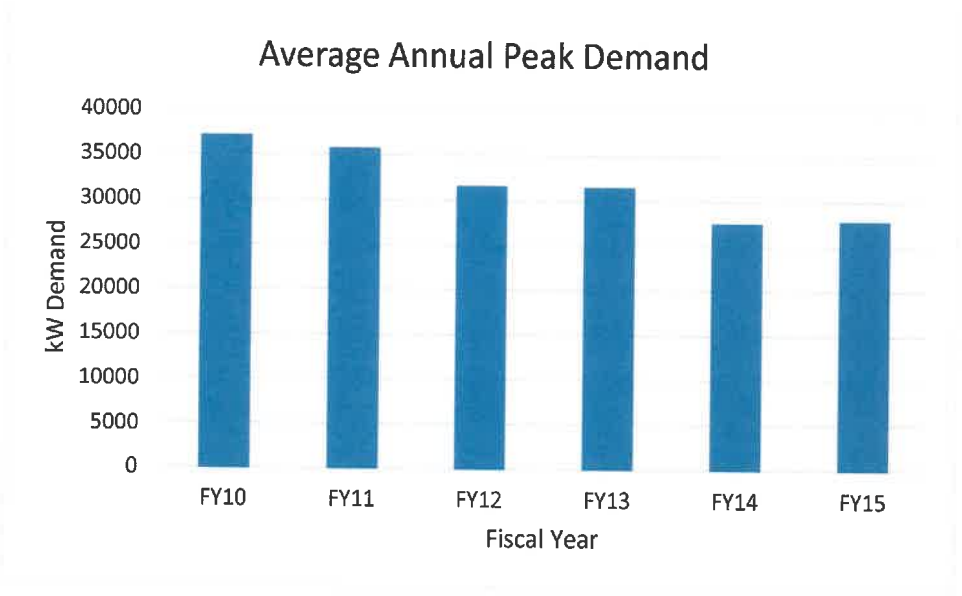


Figure 6 - Average Kilowatt (kW) Demand at KSC From 2007 to 2015

ENERGY CONSUMPTION

More than 70 percent of the energy consumed by KSC buildings is in the form of electricity. The remainder comes from natural gas, renewable energy, and miscellaneous fuels. This energy breakdown by fuel type falls in line with the energy usage of a typical building, which is illustrated in Figure 7. Most of the everyday energy consumption is due to facility lighting, space heating, cooling, and ventilation. Monthly peak demand tends to shadow major KSC operations.

The Center purchases natural gas under a DLA energy managed contract and it is delivered by FCG. Natural gas is shipped to KSC via a 12-inch natural gas pipeline that runs along NASA Parkway for distribution on KSC property. The main line then continues onto CCAFS. FCG is responsible for operating and maintaining the gas main from its station off State Road 405 up to and including meters to various facilities across KSC. Center contractors are responsible for operation and maintenance of the natural gas system downstream of the meter stations.

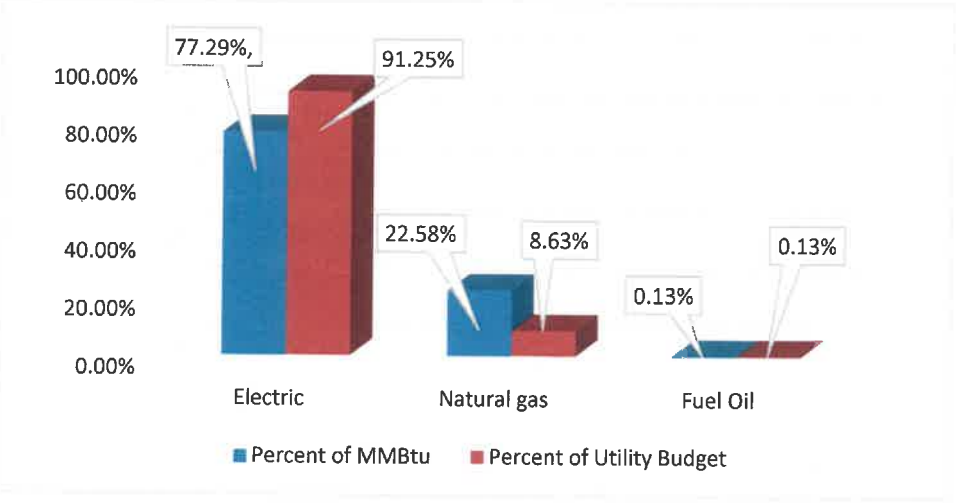


Figure 7 – Energy Consumed by Type FY, 2015

Evaluating the total KSC energy consumption allows for the identification of energy reduction as a whole and by end use. Figure 8 shows that, as a whole, the Center has seen a consistent reduction. Energy intensity reduction goals extend beyond the KSC space and utilization reduction goals, with more than a 30 percent reduction in energy intensity required, but only a 5 percent decrease in building area. The future energy consumption is very occupant-dependent, but it can be expected that if KSC continues to operate in a fashion similar to the present, there will be a steady decrease in Center energy usage. As some facilities at KSC become abandoned and readied for demolition, those low energy intensity buildings will have an unintended side effect of increasing the Center's energy intensity metric.

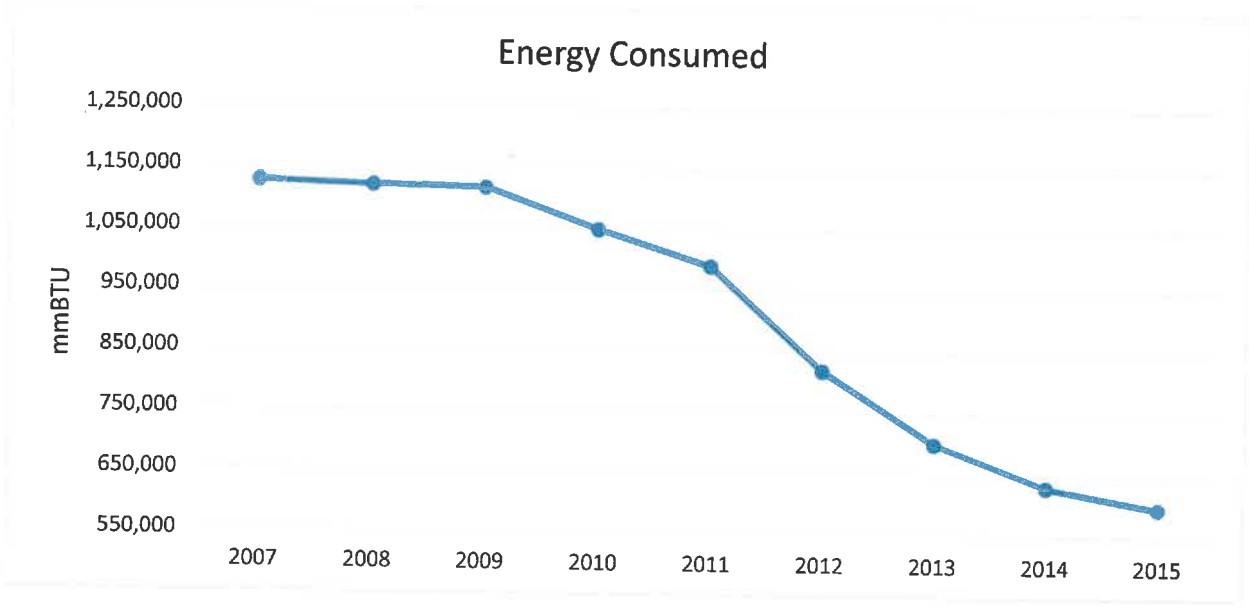


Figure 8 – Energy Consumed Over Time

To assist in tracking and sharing consumption metrics, KSC currently has a comprehensive building energy use benchmarking system called Automated Utility Database Reporting and Information System (AUDRIS) that serves multiple users. AUDRIS provides a number of services, including, but not limited to, instantaneous fuel consumption data, facility performance data, and historical account data. KSC leverages the DOE's online Portfolio Manager that provides a useful tool to track facility performance and compliance with EO 13693 guiding principles. KSC has invested resources into building a unique portfolio within the new Compliance Tracking System created by the DOE to share data across multiple agencies.

CURRENT PROGRESS

The goal for FY 2015 was a 30 percent reduction in energy intensity from the FY 2003 baseline. In FY 2015, KSC showed a reduction of 50.92 percent and did meet the goal. In FY 2015, energy (electricity, natural gas, and other fuels) costs totaled approximately $14.3 million. The goal for FY 2016 is a 2.5 percent reduction in energy intensity from the FY 2015 baseline. EO 13693 set new energy intensity reduction goals extending through FY 2025. FY 2015 is the baseline year for these new reduction goals.

PROJECTS AND INITIATIVES

ECMs and Water Conservation Measures (WCMs) are enacted on a daily basis around the Center. Awareness is further enhanced among employees through information sharing and competitions held across KSC, as well as via the EWG. As previously discussed, KSC has a goal to reduce building energy intensity 25 percent by the end of FY 2025. The FCEs performed around the Center are expected to play a dominant role in reaching the energy intensity goal.

The Center relies heavily on its primary O&M contractor to handle routine energy and water issues and to provide a consultative role for nonroutine issues. In response to energy reduction requirements stated within the contract, the contractor formed a team of dedicated engineers to promote and manage infrastructure efficiency projects that assist in meeting energy intensity goals.

In addition to large CoF projects, KSC also performs facility upgrades, recertification efforts, and infrastructure planning, with funding sometimes coming from NASA programs hosted at KSC. Examples of such energy efficiency efforts can be seen in the table below. The KSC Energy and Water Management Program is currently working on, or planning to begin work on, the projects below in an effort to meet energy intensity reduction goals. None of these projects was specifically planned with energy efficiency as the driving or primary need. Most of the drivers focused on upgrading obsolete controls and/or equipment as well as reducing O&M and utility costs. The new installed controls and/or equipment is expected to have increased efficiency; however, it has not been modeled or measured yet.

Project Control Number	Original Project Planned Start (FY)	Status	Title	Project Description	Funded Amount	
97967	2012	Construction	Replace Chilled Water Controls, Industrial Area	Replace the integrated chilled water control system at the KSC Industrial Area Chiller Plant (IACP) and at the facilities it serves.	$3M	Chiller
98889.2b	2014	On Hold	Upgrade Chillers, Booster Fabrication Facility (BFF)	Upgrade mechanical and electrical systems at the BFF Chiller Building, L6-0147. Scope consists of chilled water production upgrades.	To Be determined (TBD)	
98862	2014	Construction	Upgrade Systems, IACP	Upgrade mechanical and electrical systems at the IACP. The scope consists of chilled water production upgrades, including construction of a chilled water TES system that will reduce chilled water production cost.	$16.7M	

Project Control Number	Original Project Planned Start (FY)	Status	Title	Project Description	Funded Amount	
99000.4b	2018	Design	Replace 5 Kilovolt (kV) switchgear and chillers, Vehicle Assembly Building (VAB) Utility Annex (K6-0947)	Upgrade the Utility Annex facility. Upgrades include replacement of the 5-kV switchgear and chillers. The 5kV switchgear directly feeds the chillers and must be replaced in conjunction. The chillers, associated piping, and pumps will be replaced.	TBD	
99000.4	2018	Advertise and Award	Upgrade Systems, Utility Annex	Replace Utility Annex chillers and associated support systems (i.e., controls system, electrical switchgear, mechanical and structural systems, etc.).	TBD	
99016	2015	Construction	Launch Equipment Shop (LES), K6-1247 HVAC System Upgrade	Repair, replace, and reconfigure HVAC system components such as air handler units (AHU), boilers, and controls. Construct new HVAC mechanical rooms as add-ons to the existing facility.	$4.8M	AHU HVAC
99050	2015	Construction	Replace AHU-16, M7-0355	Replace a 40-plus-year-old AHU and associated controls in the Neil Armstrong Operations and Checkout Building (O&C) (M7-0355).	$400K	
98887	2013	Construction	Launch Complex (LC) 39 Pad B HVAC and Controls Refurbishment	Refurbish, repair, and upgrade HVAC systems inside the Pad B perimeter and in the Operations Support Building (OSB) (J7-0689) and Logistics Building (J7-0688).	$6.4M	

Project Control Number	Original Project Planned Start (FY)	Status	Title	Project Description	Funded Amount	
98890	2012	Construction	Lighting Upgrades For Facility Infrastruc-ture	Design-build lighting systems upgrades at facilities, including Engineering and Administration Building Complex (L6-0146, L6-0247, L6-0248, L6-0249, L6-0295, and L6-0297), Engineering Development Lab (M7-0409), Space Station Processing Facility (SSPF) (M7-0360), Multi-Payload Processing Facility (M7-1104), and VAB (K6-0848).	$854K	Lighting
98890.1	2013	Construction	Lighting Upgrades For Facility Infrastruc-ture, Phase 2	Design-build lighting systems upgrades at facilities, including LES, Rotation Processing Surge Facility, and the Logistics Facility.	$350K	
98890.1a	2013	Construction	Upgrade Lighting, Launch Control Center (LCC) (K6-0900)	Design-build lighting systems upgrades at the LCC (K6-0900).	$419K	
99031	2016	Construction	Upgrade Lighting, Various Buildings	Upgrade lighting systems at facilities such as SSPF (M7-0360), Cryogenics Test Laboratory (M7-0557), Prototype Shop (M7-0581), Payload Support Building high bay (M7-0505), LES high bay (K6-1247), the Logistics Facility high bay (K6-1547), and the first floor of OSB II (K6-1249). Scope includes replacing	$2.4M	

Project Control Number	Original Project Planned Start (FY)	Status	Title	Project Description	Funded Amount	
				existing lighting with high efficiency LEDs.		

Table 2: KSC Projects

REQUIRED ACTIONS

To continue to meet the energy intensity goals, KSC must comprehensively identify and implement no-cost, low-cost, and capital-intensive energy conservation projects. There are several requirements for new construction and major rehabilitation projects, including:

- If they are life-cycle cost-effective, new Federal buildings must be designed to achieve energy consumption levels at least 30 percent below the American Society of Heating, Air Conditioning, and Engineering (ASHRAE) Standard 90.1 (EPAct of 2005). (For guidance on life-cycle cost-effectiveness, see Life-Cycle Costing Manual for the FEMP [NIST Handbook 135, 1995 edition].)
- For CoF projects, all new construction and major building renovation projects planned for award after October 1, 2005, shall meet the minimum LEED Silver rating (NPR 8820.2G).
- New Federal buildings and Federal buildings undergoing major renovations shall be designed so that the fossil fuel-generated energy consumption of the buildings is reduced, from an FY 2003 baseline, by the following percentages (in accordance with EISA 2007):

Fiscal Year	Percent Reduction
2010	55
2015	65
2020	80
2025	90
2030	100

Table 3: Fossil Fuel Reduction

- Ensure 15 percent of the Agency's existing buildings (above 5,000 GSF) meet the revised Guiding Principles by FY 2025 and that the Agency makes annual progress toward 100 percent conformance with the Guiding Principles for its building inventory (EO 13693).
- Beginning in 2020, all new Federal buildings (greater than 5,000 GSF) that enter the planning process are designed to achieve energy net-zero and, where feasible, water or waste net-zero by 2030 (EO 13693).

NASA has developed a Net-Zero Energy Buildings Roadmap to assist in achieving the energy net-zero goal.

PROJECTS AND INITIATIVES

KSC has a list of energy projects needing further development that range from mechanical system upgrades to lighting replacement from existing ECMs. The projects offer a range of financial payback periods. The Center has particular interest in projects that have less than a five-year payback and typically will not fund projects that have more than a ten-year payback. As the Center continues to audit existing facilities, many more ECMs are expected to be identified. The Center plans to research and possibly implement advanced energy management and control systems with analytics, as well as Building Automation Systems. A list of candidate, bundled projects is shown in Table 4.

Facility ID/Name	Project Description	Estimated Project Cost ($k)	Anticipated Savings ($k)	Anticipated Savings (MWH)	Projected Implementation Date (FY)
Various	KSC Facility Insulation Efforts	1600	178	2373.3	2025
Various	Miscellaneous Lighting	4700	635	8466.7	2025
Various	Miscellaneous Mechanical Upgrades	1339	302	4026.7	2025

Table 4: Planned Energy Projects and Initiatives

RISKS

Challenges include energy cost inflation and environmental regulation changes. For example, requirements imposed by the National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines (RICE-NESHAP) recently placed a large financial burden on KSC. Continued participation in FPL's Commercial Industrial Load Control (CILC) program required upgrades to onsite generators with a capacity of more than 11 MW. The CILC program makes KSC eligible for a reduced unit cost for electricity. As a participant, KSC agrees to provide backup power generation when FPL is experiencing abnormal peak energy demand. So far the cost break has resulted in a savings of $760,000 per year. The savings were partly offset when KSC invested $1.6 million to upgrade CILC-affected generators to meet the RICE-NESHAP regulations and enable continued participation in the CILC program. Considering changing environmental regulations and with a large infrastructure to maintain, KSC has cost risks due to future policy updates.

In addition to CILC agreement burdens, FPL has notified KSC of an FPL proposal to the Florida Public Works Commission that will increase KSC's electricity rate by 43 percent from the 2016 level. The FPSC recently

approved a 17 percent rate increase to be phased in from FY 2017 through FY 2020. Although a large cost increase is not helpful to KSC's budget, it will provide further justification for energy-related projects because the return on investment (ROI) will be better.

KSC infrastructure risks include increased O&M costs due to age-related deterioration of existing buildings and equipment. The decay is exacerbated by KSC's corrosive coastal environment. In many cases, the equipment and systems have been continuously operational for 25 to 30 years, long past their intended life.

EXPECTED OUTCOMES

The Center expects to meet its energy reduction goals. However, existing weaknesses associated with an aging infrastructure will be an ongoing challenge. Historically, the Center has been very successful in reducing energy use and will continue that pursuit. Significant energy reductions will be increasingly difficult to identify. Ever-rising utility rates are another concern. While these are all factors at KSC, Center personnel pursue continuous improvement in their functional areas. To that end, KSC anticipates it will always be advantageous to pursue energy and water efficiencies in an effort to reduce our footprint in ways that allow more resources to be applied toward NASA's core missions and objectives. Despite the intensity reduction goals growing annually and an increasingly smaller budget, KSC will seize every opportunity to close gaps as they are identified.

RENEWABLE ELECTRIC ENERGY

LONG-TERM GOALS

EO 13693 provides new renewable electric energy targets from those listed in the EPAct of 2005 and EO 13423. The newer EO states that each agency is to ensure that the percentage of the total amount of building electric energy consumed by that agency, that is renewable electric energy, is as shown below:

- Not less than 10 percent in FY 2016 and 2017
- Not less than 15 percent in FY 2018 and 2019
- Not less than 20 percent in FY 2020 and 2021
- Not less than 25 percent in FY 2022 and 2023
- Not less than 27.5 percent in FY 2024
- Not less than 30 percent in FY 2025 and each year thereafter

The Center is confident it will reach the renewable electric energy goals and has a proven track record of doing so. To further this pursuit, in June of 2016, KSC issued a public Notice of Availability seeking land-use proposals involving renewable energy, among other things. Even though KSC is in an ideal location for solar power generation and already has a variety of operational solar applications like the solar thermal system pictured below, the Center is willing to give all renewable energy proposals serious consideration. Preliminary discussions with FPL appear to indicate that they intend to provide a proposal for installing additional solar power generation in the range of 30 MW and possibly up to 75 MW. The Center is hopeful that a new EUL agreement can be reached with FPL.

KSC has a pristine natural habitat as well as hundreds of acres that have been disturbed for many decades. Disturbed land that is not converted back into natural Florida habitat might be suitable for biomass conversion projects. Some desirable projects would be those that focus on harvesting invasive plant species such as Brazilian pepper trees. For example, converting biomass into fuel could provide the Center with an economic baseline from which to track advances in conversion technologies and help determine when a full-scale operation is warranted. The resulting fuel could be used onsite in vehicles or to generate electricity.

More than ten years ago, FPL proposed installing and maintaining four traditional horizontal hub-and-blade turbine systems at KSC as a low-wind test bed that could generate up to 10 MW of power. KSC is one of very few places in Florida with average wind speeds suitable for such a project, as depicted in Figure 9. NASA management on Center was supportive, but the Fish and Wildlife Service (FWS) rejected the proposal, deeming it to be incompatible with the goals of a wildlife refuge. There was also pushback from private residents who felt it would disturb their view of the horizon.

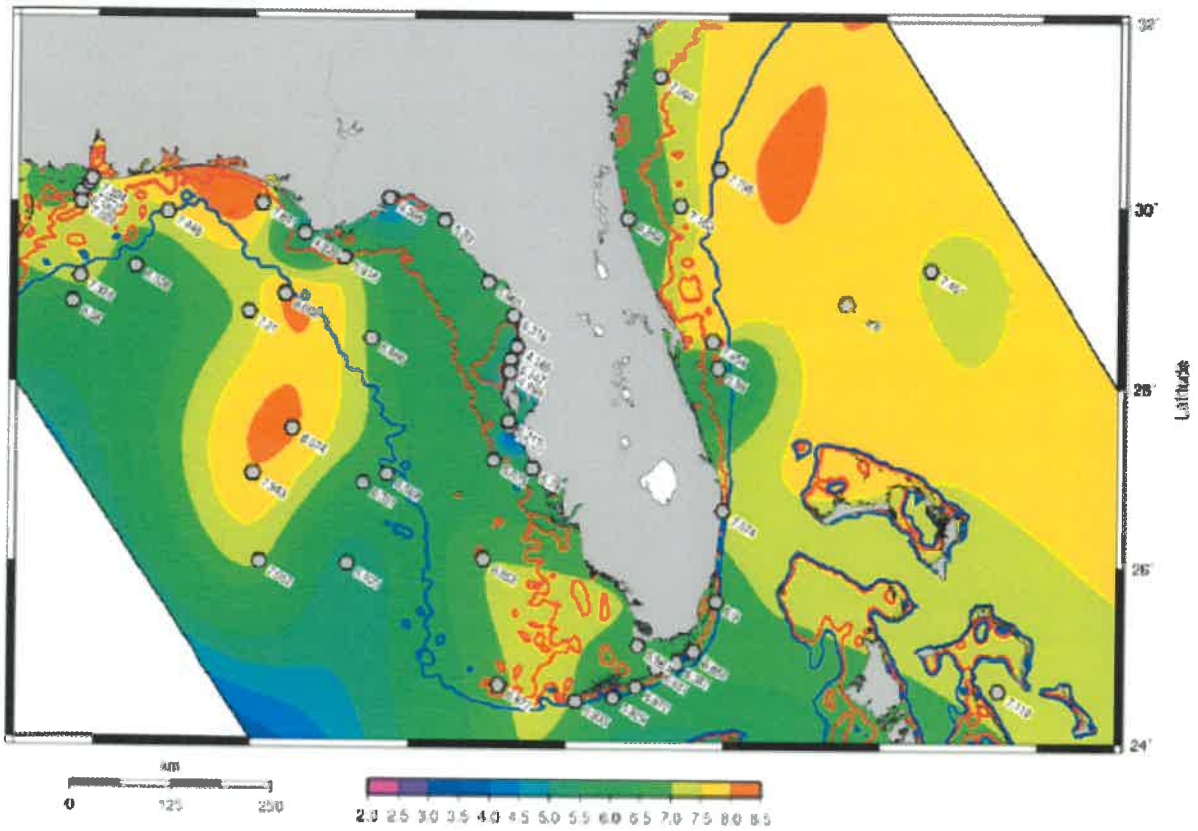


Figure 9: Average KSC Winds 13–18 mph

Recent technological advances have led KSC to revisit the possibility of finding ecofriendly solutions to harnessing wind power. For example, several companies have been experimenting with bladeless wind turbine configurations. One such device looks like a pole; thicker at the top than at its base, it generates electricity by taking advantage of the pole's natural vibrating frequency, also known as resonance, when buffeted by wind. Resonance is the physical property that dramatically destroyed the Tacoma Narrows Bridge, but in this case is harnessed to create electricity. Another company has developed what they call a "Windstalk" design that, in part, uses the piezoelectric effect. Other designs use airfoils in various configurations to induce either a reciprocating or an oscillating motion to generate electricity. Many of these systems have far fewer parts than a hub-and-blade system, are simpler to install and maintain, and were derived, in part, as an attempt to assuage environmental concerns. Currently, these designs lack sufficient operational run time, without which economic viability can be difficult to ascertain.

Tethered aerial systems are another option recently considered. Flying at 1,000 to 3,000 feet above ground level, they are able to take full advantage of steady, higher-velocity winds aloft. The altitude also gets them well above the domain of most birds, and they are easily seen by birds that fly that high. They typically have automated flight control systems that include automatic retraction during weak or severe wind conditions and use either the wind itself to get aloft and stay aloft like a kite, or a lighter-than-air system (e.g., helium) to stay airborne. The systems are compact, easily deployed to wherever needed, and can double as a communications platform, making them ideal for months of disaster relief or use in remote regions. The DOD and some construction firms have deployed them in a number of areas

worldwide. At first glance they do not seem to be cost-effective yet when tied into a healthy, fixed power grid, further analysis is needed. Neither is it known at this time if the FWS or general public would be receptive to a compact aerial design.

FWS concerns with traditional hub-and-blade systems are identified in their policy on wind turbines. Their placement requirements include:

1. Avoid placing turbines in documented locations of any species of wildlife, fish, or plant protected under the Federal Endangered Species Act.
2. Avoid locating turbines in known local bird migration pathways or in areas where birds are highly concentrated. Examples of high concentration areas for birds are wetlands, state and Federal refuges, etc.
3. Avoid placing turbines near known bat hibernation, breeding, and maternity/nursery colonies; in migratory corridors; or in flight paths between colonies and feeding areas.

Figure 10 shows an ideal location for wind generation at KSC.

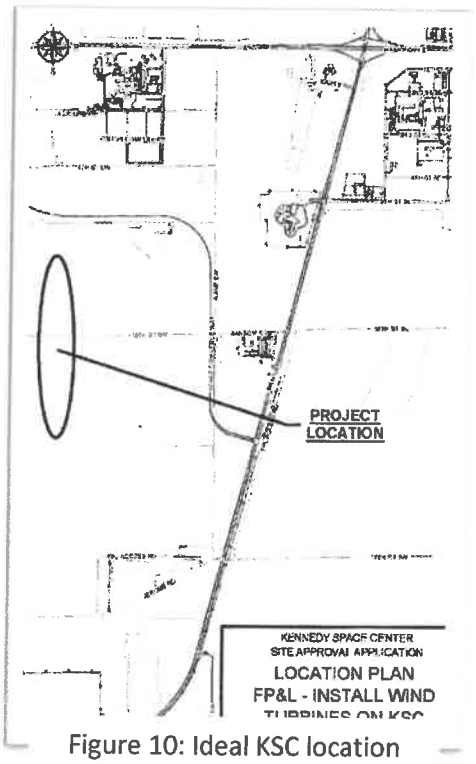


Figure 10: Ideal KSC location for wind generation

Because the seemingly bird-friendly systems described here are fairly new, it could be several years before one or more are deemed economically, environmentally, and politically feasible at KSC. As a technology reference point, FPL typically does not deploy cutting-edge renewable energy systems, instead preferring to reduce their risk by installing systems with well-established performance and maintenance records.

Having a workforce willing to explore other new technologies, like capturing energy from tides, waves, geothermal, and more, is critical. To assist in these emerging technologies, KSC has the advantage of fully-engaged local utility companies that support the Center's quest for renewables and reaching the 2025 goal.

RENEWABLE ELECTRIC ENERGY AND DEMAND

Renewable electric energy use and production reduces nonrenewable energy demand and consumption. For KSC, renewable electric energy sources include solar panels at the Propellants North Facility (roof-mounted and awning-mounted), a solar farm in the Industral Area, a solar collector heating water at the Film Storage Building (Figure 11), solar panels powering the weigh station at KSC's landfill, and a geothermal heat pump servicing the Ordnance Operations Facility. These sources support the reduction of nonrenewable energy demand. Understanding how renewable electric energy use and production affects nonrenewable energy demand is important. In addition, understanding this relationship allows

for estimating annual budget (utility costs), negotiating utility contracts, and tracking base demand, peak demand, and any reductions in demand due to projects, building optimization, or other Energy and Water Management Program activities.

Figure 11: Film Storage Building Solar Thermal Application (Installed FY 2003)

RENEWABLE ELECTRIC ENERGY CONSUMPTION

Current progress toward renewable energy goals at KSC is excellent since the Center has a considerable amount of onsite solar power generation that is further supplemented with the purchase of RECs. Purchasing RECs effectively subsidizes the cost of renewable energy installations elsewhere in the country. Federal agencies must also ensure that purchased RECs come from renewable energy sources placed into service within ten years prior to the start of the fiscal year. For FY 2015 and FY 2016, KSC purchased two years of RECs at once instead of buying them separately each year. This saved money since utility rates are at historic lows.

In terms of local renewable energy installations, there are three (one in construction) existing solar fields on KSC-owned property:

- The FPL-owned and -operated PV field, located near the corner of Simons Avenue and North Courtenay Parkway on approximately 57 acres of KSC-owned land, is rated to generate a maximum of 10 MW of electricity for Merritt Island.
- The NASA-owned and FPL-operated PV field, located adjacent to and connecting with the Orsino substation, is rated to generate a maximum of 1 MW of electricity within the KSC grid on a 6-acre site while avoiding approximately $150,000 in purchased power cost annually (per AUDRIS, PV Array Reports, FY 2011 to FY 2014).

- In FY 2015, a new $6.8 million CECR contract was awarded to expand our existing 1-MW facility by another 2 MW of PV energy. This expansion will be independent of FPL, but located adjacent to the 1-MW facility (Figure 12).

Note: In accordance with DOE guidelines, energy production from the 10-MW plant is counted toward KSC's renewable energy goal due to its location on KSC property, and as long as KSC purchases an equivalent amount of RECs.

Figure 12: New $6.8 Million 2-MW PV Field Under Construction W

As renewable energy systems are installed, the process for providing O&M is evaluated and implemented uniquely. The primary O&M topic that arises in any renewable energy installation is the concept of purchasing renewable energy as a product versus purchasing it as a service. In the prior example, the FPL and KSC EUL is an example of renewable energy provided as a service where O&M services are provided not only throughout the full 30-year installation life cycle but also on a day-to-day basis to ensure performance measures are met and that the investment proves successful. An example of renewable energy installed as a product is the 78-kW roof-mounted solar installation at the Propellants North Facility, completed in 2010. This project revealed an unexpected significant weakness to the "product" approach for renewables. It took more than three weeks before the system operator discovered the panels were no longer in service due to a failure of the onsite inverters. Because the inverter failure was not electronically communicated and there was no plan to monitor system performance, the solar panels

were left off numerous times for up to five weeks. A lesson learned for KSC is that solar installations require long-term commitment and continual observation to ensure efficient performance.

CURRENT PROGRESS

The renewable energy goal for FY 2015 was 10 percent renewable energy consumption. In FY 2015, 18.5 percent of KSC's energy consumption came from renewable sources and through the purchase of RECs, thus exceeding the goal. In FY 2015, RECs cost KSC $3,055. The goal for FY 2016 is 10 percent renewable electric energy consumption. EO 13693 set new renewable electric energy goals, extending through FY 2025, that KSC intends to meet through self-generated renewables (SGRs), hosted renewables, and the purchase of RECs.

PROJECTS AND INITIATIVES

The KSC Energy and Water Management Program is taking the following actions in an effort to meet these goals:

Facility ID/Name	Project Description	Estimated Project Cost ($Thousands)	Anticipated Savings ($Thousands)	Anticipated Savings (MWh)	Implementation Date (FY)
M6-0900	Complete KSC Industrial Area Solar Plant	6800	294	2441.8	2018
None	Purchasing RECs	Varies	0	0	Varies

Table 5: Renewable Projects and Initiatives

REQUIRED ACTIONS

In order to continue to meet the increasing renewable electric energy use goal, KSC must continue to identify and implement no-cost, low-cost, and capital-intensive renewable electric energy projects. There are several requirements for new construction and major rehabilitation projects. Requirements are included in the EPAct of 2005, NPR 8820.2G, EISA of 2007, and EO 13693.

The first required action for improving KSC's implementation of renewable energy systems is promoting integrated renewable energy systems similar to what was done at the Propellants North Facility, where roof-mounted solar panels were installed.

RISKS

Onsite solar installations that are improperly managed and maintained will not perform to their predicted capabilities, and KSC will not experience a full ROI. As a secondary risk in that case, since the overall production of renewable energy will be less, KSC will be required to purchase additional RECs to meet renewable energy generation requirements.

In addition to performance risks associated with improper maintenance practices, local weather conditions present challenges to PV installations. Cloud cover reduces overall PV panel efficiency and storms produce damaging winds, flooding, and lightning hazards. The air at KSC has a fairly high salt content, making corrosion on electronic equipment another concern. For these reasons, warranties are extremely important to ensure reduced risk for these long-term investments.

A final risk applicable to all renewable energy installations is cost inflation. Renewable energy purchases traditionally have long payback periods, subjecting the cost benefit over time to cost inflation. For example, if electricity cost goes down, the renewable energy installation savings equally go down. The investment return timeframe then potentially exceeds the expected renewable energy installation life. Risk in this case lies within the timeframe of a typical renewable energy installation, which is often a greater time length than standard ECMs.

EXPECTED OUTCOMES

KSC expects to meet the goal of 10 percent electricity via renewables by investing in renewable energy resources and purchasing RECs. KSC has developed a process to determine when renewable energy installations are cost-effective for CoF projects. This process entails analysis of the facility type, roofing materials, site orientation, and economic conditions. Renewable energy installations are recommended to the project manager when the process indicates the installation is cost-effective. Given the aggressive EO goal by FY 2025, KSC predicts the increased necessity of purchasing RECs to make up the delta in meeting renewable and clean energy goals.

CLEAN ENERGY

LONG-TERM GOALS

In addition to renewable electric energy goals, EO 13693 introduced clean energy, a combination of renewable electric energy and alternative energy. It states that each Agency is to ensure that the percentage of the total amount of building electric energy and thermal energy shall be clean energy, accounted for by renewable electric energy and alternative energy:

- Not less than 10 percent in FY 2016 and 2017
- Not less than 13 percent in FY 2018 and 2019
- Not less than 16 percent in FY 2020 and 2021
- Not less than 20 percent in FY 2022 and 2023
- Not less than 22.5 percent in FY 2024
- Not less than 25 percent in FY 2025 and each year thereafter

CLEAN ENERGY AND DEMAND

Clean energy use and production reduces nonrenewable energy demand. For KSC, clean energy sources, including solar, solar thermal, and geothermal systems, support the reduction of nonrenewable energy demand. Understanding how clean energy use and production affects nonrenewable energy demand is important. That relationship enables estimating annual budget (utility costs), negotiating utility contracts, and tracking base demand, peak demand, and any reductions in demand due to projects, building optimization, or other Energy and Water Management Program activities.

Currently, KSC invests in clean and renewable energy based on a reasonable ROI and when the opportunity is advantageous to achieve LEED certification and credits. KSC also seeks to first identify renewable and clean energy projects prior to investment in RECs, where feasible.

RENEWABLE ELECTRIC ENERGY AND CLEAN ENERGY CONSUMPTION

The following (Figure 13) is a list of the existing SGRs on Center and their most recent (FY 2015) consumption. This list excludes the aforementioned FPL 10-MW solar hosted renewable.

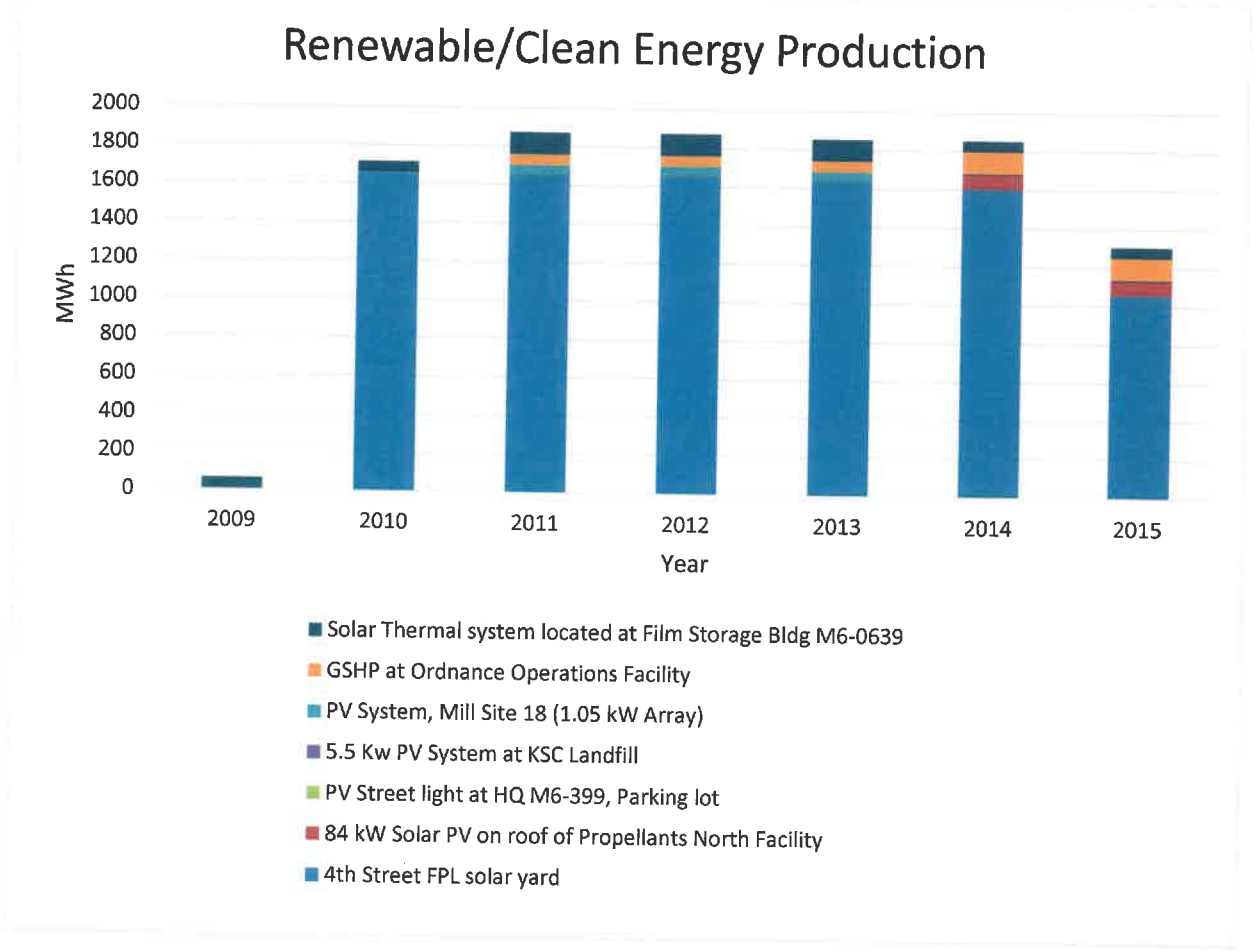


Figure 13: Self-Generated Renewables

CURRENT PROGRESS

EO 13693 added clean energy goals for the first time. The clean energy goal for FY 2016 is 10 percent clean energy consumption. Clean energy is a combination of renewable electric energy and alternative energy. While nuclear energy is considered a clean energy source, the local electric company, FPL, does not have any nuclear plants located near KSC, so the Center cannot take any credits for it.

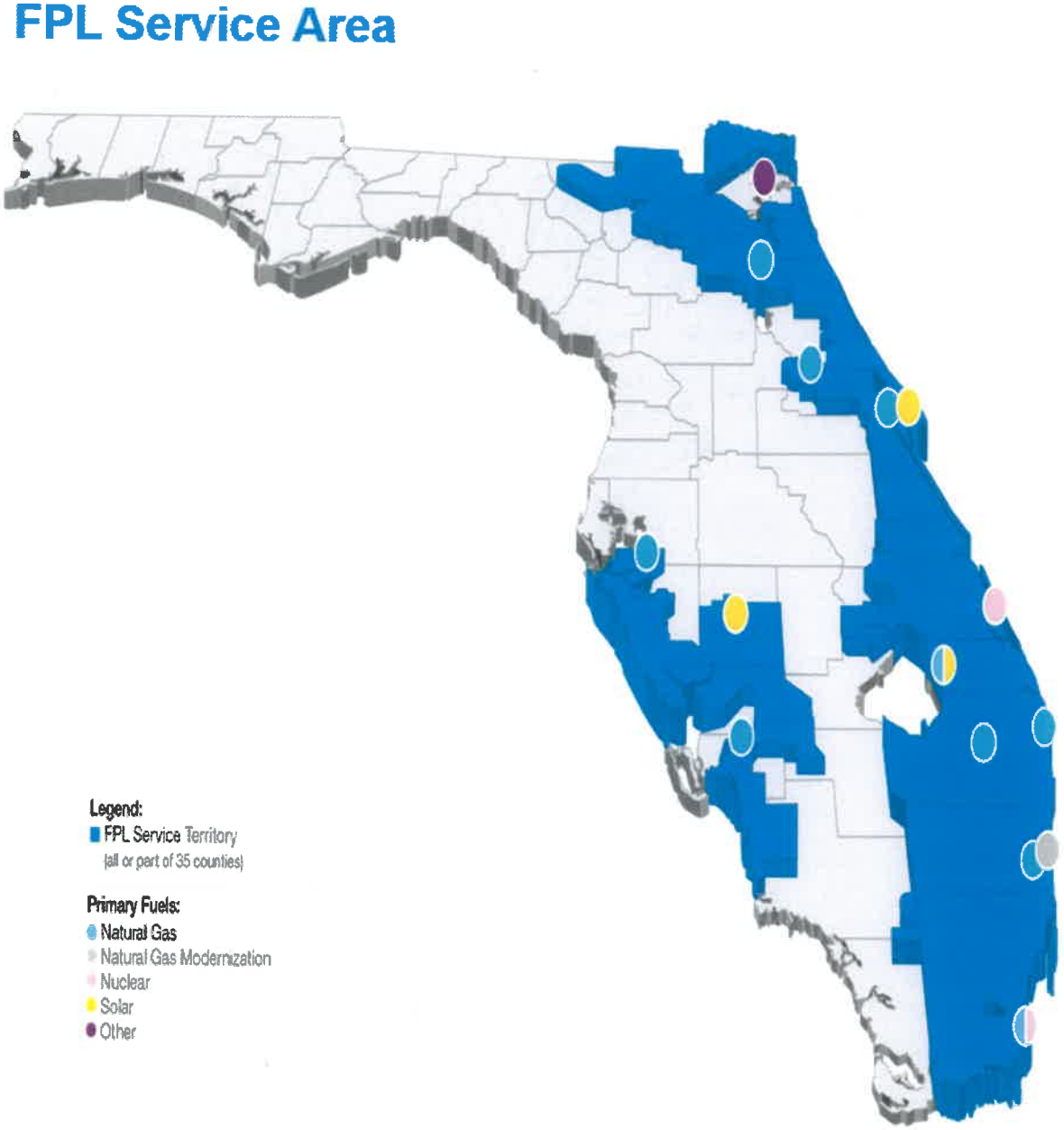


Figure 14: FPL Service Area

PROJECTS AND INITIATIVES

In addition to the renewable energy actions mentioned above, the KSC Energy and Water Management Program is further targeting clean energy by seeking ways to incorporate CHP systems into KSC's infrastructure. As HVAC systems reach the end of their service life, KSC personnel are investigating cost-effective CHP alternatives to traditional replacement options. So far, no KSC facilities have been identified as good candidates for CHP applications.

REQUIRED ACTIONS

In order to continue to meet the clean energy use goal, KSC must comprehensively identify and implement no-cost, low-cost, and capital-intensive renewable electric energy and clean energy projects. There are several requirements for new construction and major rehabilitation projects. Requirements are included in the EPAct of 2005, NPR 8820.2G, EISA of 2007, and EO 13693.

RISKS

As long as KSC relies primarily on solar panels for renewable energy, the risks identified for meeting clean energy goals are identical to those mentioned for renewable electric. Obviously some forms of clean energy (e.g., geothermal) are not affected by cloud cover and have a low risk of storm damage. Should KSC alter its current mix of clean energy systems, this section will be updated accordingly.

EXPECTED OUTCOMES

KSC expects to meet the clean energy goal mostly due to the synergy from the renewable electric energy goal. Onsite renewable options, the purchase of RECs, and investing in clean energy resources will continue to be sought. KSC has developed a process to determine when clean and renewable energy installations are cost-effective for CoF projects. This process entails analysis of the facility type, roofing materials, site orientation, economic conditions, and more. Renewable and clean energy installations are recommended to the project manager when the process indicates the installation is cost-effective. Given the aggressive EO goal to be met by FY 2025, KSC predicts the increased necessity of purchasing RECs to make up the delta in meeting renewable and clean energy goals.

WATER

LONG-TERM GOALS

The KSC water distribution system was designed and constructed in the 1960s and was sized for future space launch capabilities as well as fire demand and potable water needs. Since the 1960s, water quality standards have become more stringent. As a result of the relatively newer water quality standards, flushing has been necessary in order to meet those more stringent standards. To meet the EO 13693 goal of reducing water intensity (gallons per gross square foot [GAL/GSF]) of 36 percent by the end of FY 2025 (from an FY 2007 baseline), KSC is working on pipe size, flush point reductions, and O&M optimization. Goals for water intensity reduction include:

- 2 percent annually through the end of FY 2025
- 36 percent by the end of FY 2025

The KSC FY 2007 baseline water intensity is 38.6 GAL/GSF. The 36 percent reduction target for FY 2025 is 24.7 GAL/GSF.

WATER DEMAND

Water demand is the water required to operate a facility and provide fire protection. For KSC, water is provided by the City of Cocoa as well as an emergency interconnect to the 45th Space Wing (45 SW) at CCAFS. Awareness of Center water demand is important and allows for estimating annual budget (utility costs), negotiating utility contracts, and tracking base demand, peak demand, and any reductions in demand due to projects, building optimization, or other Energy and Water Management Program activities. Potable water for KSC is purchased from the City of Cocoa at a base rate of $1,667.26 and a two-tiered pricing schedule of $2.61 per thousand gallons for the first 21 million gallons and $4.99 per thousand gallons for every gallon thereafter. KSC's wastewater is conveyed to CCAFS for treatment and disposal. The 45 SW provides sewer services as a percentage of the operational cost of maintaining the treatment plant based on the percentage of flow from KSC.

WATER CONSUMPTION

The FY 2015 annual equivalent water intensity reduction compared to the baseline year is due to a combination of more efficient facilities, recent water and wastewater infrastructure upgrades, increased conservation awareness, and better consumption practices. A CoF project replacing water and wastewater infrastructure is currently planned to begin in FY 2017 and has some potential to again improve KSC's intensity metric. As with previous upgrades, additional flushing will be required to maintain water quality throughout construction. This will likely cause KSC to miss water intensity targets in the near term but will result in long-term efficiency gains as the plumbing is right-sized and dead ends are eliminated to be commensurate with the Center's population and needs.

KSC has achieved a reduction in water consumption of approximately 27 percent from 2007 to 2015. Despite this significant change, the Center's water intensity metric has only dropped 18 percent over that same period. This is due to intensity being a measure of gallons used per square foot of facility space, and KSC's robust facility demolition program, which has been removing facilities that historically had little or no water usage.

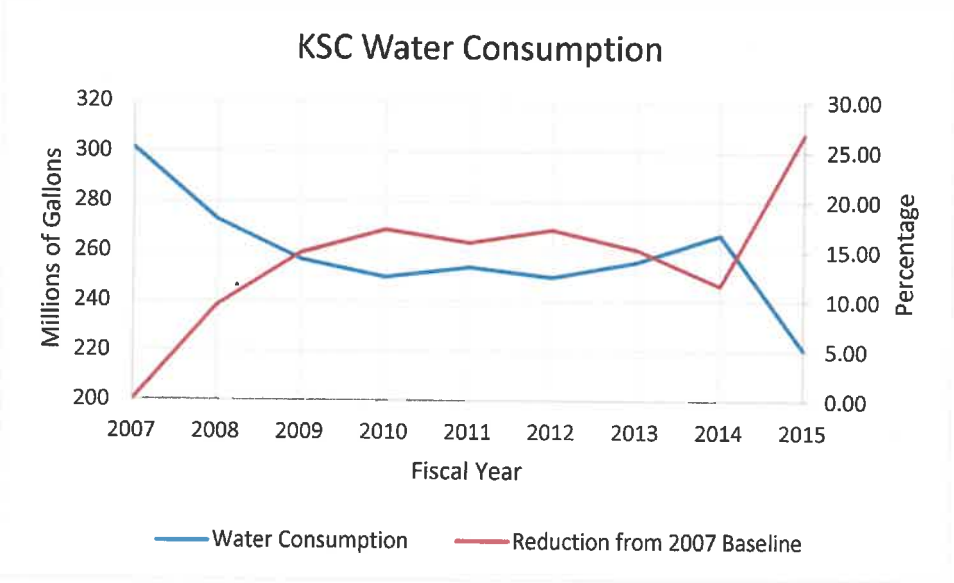


Figure 15: Water Consumption

CURRENT PROGRESS

In an effort to help meet water intensity reduction goals, the following projects are planned but have not yet been funded:

- Install water meters at additional locations to better understand flows and usage at the Center.
- Update to the KSC Water System Model following the completion of the upcoming Phases 5 and 6 projects to also better understand flows and usage at the Center.
- Explore possible rainwater or geothermal or related technologies for the larger combined chillers, IACP, and Utility Annex to reduce the water consumed.
- Develop water efficiency standard specific to KSC.

Partnership agreements for facilities at KSC that are turned over for commercial use typically include a requirement for the user to pay for water meter installation. If a meter is not installed, water usage is estimated by other means as agreed to by NASA KSC and the user, who is then billed accordingly.

PROJECTS AND INITIATIVES

The following table lists water projects that are either underway or shovel-ready and awaiting funding. These projects will improve reliability and redundancy for the Center and reduce O&M costs associated with an aging infrastructure.

PCN	Original Project Planned Start Date (FY)	Status	Title	Project Description	Funded Amount
96968.4	2007	Advertise and Award	Revitalize Water and Wastewater Systems, Phases 5 and 6	This project will replace water lines throughout the KSC water distribution system. Pipeline replacement is to include critical water mains, facility service lines, valves, and fire hydrants.	N/A

Table 6: Water Projects and Initiatives

REQUIRED ACTIONS

Until recently most of KSC's water distribution system was more than 50 years old and had exceeded its expected service life. Previously, various water and sewer system failures had resulted in unscheduled outages and costly emergency repairs. As part of ensuring that the water distribution system will be usable for another 50 years, the Agency funded a multimillion dollar revitalization project aimed at improving water quality and distribution system reliability.

The revitalization project has six phases, with the final phase scheduled for completion in 2018. This project will improve KSC water quality, replace and repair aging infrastructure, improve monitoring systems, enhance fire water flow, and replace septic systems. In addition to meeting water quality standards and reducing water consumption, estimated annual savings are over $1 million from reduced water distribution system O&M costs.

In order to continue reductions in water consumption intensity, KSC must also continue to aggressively identify and implement no-cost, low-cost, and capital-intensive water conservation projects. Actions along these lines include continuing to design, specify, and install water efficiency measures in all new and replacement equipment. The Center will also have the EWG and WWG promote water efficiency by providing signage across KSC that increases awareness among the workforce. To ensure continual performance, the Center is installing water meters at the building level as funding permits.

PROJECTS AND INITIATIVES

As the six phases of the extensive effort to repair KSC's 50-year-old-plus water and wastewater system come to completion, it is anticipated that additional projects and/or operational changes will be necessary in order to meet the necessary water intensity reductions. The water system hydraulic model should be updated after the completion of the six phases, which may result in additional improvements that would result in a reduction of flushing.

In addition, the WWG and O&M community is evaluating 38 separate ECMs for consideration to become projects, each ECM has an average payback of 38 years due to very low water costs. Other ECMs will be generated as FCE are completed in the next several years.

RISKS

Risks include water quality and population trends. Low water quality and flushing required to meet water quality standards are a challenge for three primary reasons: water age is already somewhat marginal once it reaches KSC, extensive flushing is needed to maintain water quality on a number of lines, and the current infrastructure is oversized in relation to the Center's population. A series of CoF projects have addressed some of these challenges. However, since water intensity is measured in terms of gallons consumed per GSF, water efficiency appears to diminish when the Center population increases because there is not a proportional increase in square feet. In addition, as low water-intensity facilities are excluded from the goal (typically due to demolition efforts), the square foot measurement will drop with little or no change in Center consumption. Water intensity, then, can be a misleading metric that may not accurately reflect the Center's water conservation efforts.

In 2016, the Center's Authoritative Facility List showed 48 NASA-operated buildings inside the KSC perimeter that are slated to be demolished by 2021, pending funding availability. This represents a reduction of more than 643,000 SF that will directly affect KSC's water intensity numbers. While the Central Campus Phases 1 and 2 new construction projects are planned to eventually restore 346,553 SF of new facility space, the Center's overall footprint is on a downward trend, with more reductions planned beyond 2021. In addition to the above challenges, another risk in meeting the water goal is timing. Significant water reduction projects are typically implemented through funding mechanisms that take several years to put in place, making it unrealistic to expect they will help meet any near-term annual goals.

EXPECTED OUTCOMES

The FY 2025 water intensity goal is daunting considering KSC's challenges mentioned above. As with any goal linked to infrastructure square footage, as KSC continues to demolish unneeded facilities, water intensity performance will appear to decline despite actual water usage remaining essentially level. As revealed in the figure below (Figure 16), KSC's may not meet the required water reduction intensity reductions in FY 2018 and beyond. Unless even more significant efforts are made to improve KSC's water infrastructure, the annual water intensity reduction goal will likely not be met.

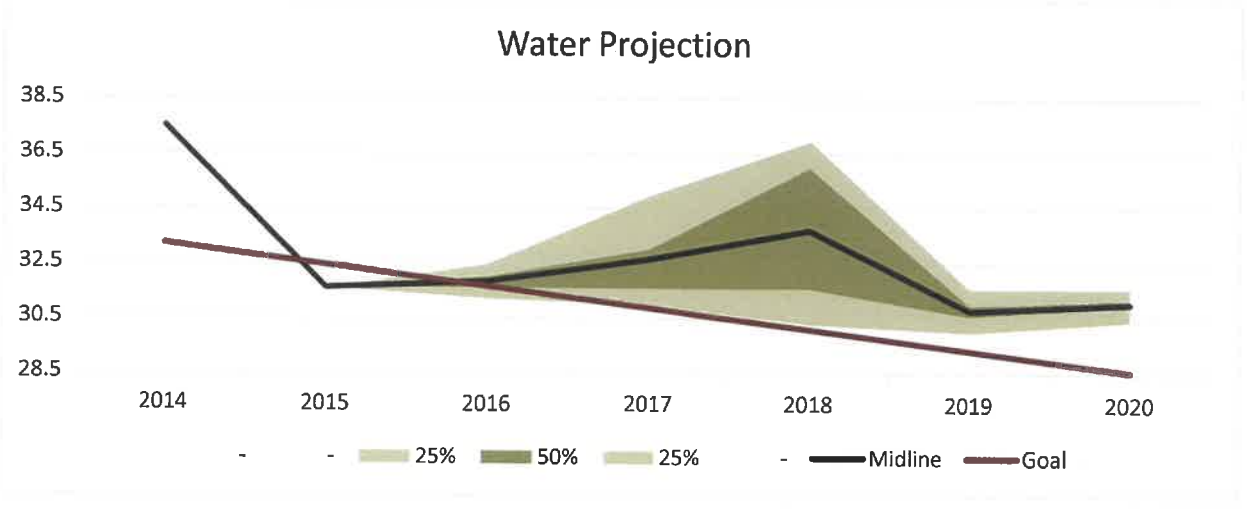


Figure 16: Water Projections

The above graph represents output from a predictive model concerning KSC water intensity. It takes into account KSC subject matter expert estimations of impacts from currently planned projects. The midline depicts an average viewpoint, while the 50 percent and 25 percent regions pertain to the likelihood of deviation from the midline. As shown, water intensity expectations vary significantly while construction is underway through 2018, but converge again by 2019.

OPERATIONS AND MAINTENANCE

PROCEDURES

KSC ensures O&M procedures include actions that produce energy and water savings. Standard operating procedures within the Center-wide O&M services contract include:

- All HVAC equipment is periodically serviced to ensure proper operation and maximum efficiency.
- Energy Management and Control Systems (EMCS) technicians work closely with the Energy and Water Manager to identify energy reduction opportunities through modifying HVAC equipment sequence of operations.
- EMCS controlled lighting is shut off during nonoperational hours.
- Facility commissioning opportunities within energy audits are highlighted as immediate- and low-investment cost saving opportunities.
- Contractor facility managers for all primary facilities follow standard facility checklist procedures to ensure efficient operations.
- Approved standard temperature setpoints are used to ensure HVAC operation consistency and low-cost measures.

- All chiller plants are periodically serviced to ensure proper operation and maximum efficiency.
- Low-flow water fixtures replacement measures are specified within existing facilities.

PROCESS IMPROVEMENTS

KSC has a very integrated community when it comes to O&M improvements. The O&M staff works with the energy and water teams, the CoF group, and the EWG and WWG to best determine the prime locations to invest efforts. KSC employees are continually y looking for ways to streamline O&M conservation efforts Center-wide.

METERING

In accordance with EISA 2007 Section 432, Agencies are required to identify all "covered facilities" that constitute at least 75 percent of the Agency's facility energy use. These covered facilities must be benchmarked by entering meter data into the ENERGY STAR® Portfolio Manager. Section 434 required Agencies to provide for equivalent metering of natural gas and steam by October 1, 2016. In addition, EO 13693 sets requirements for installing advanced meters on all data centers by 2018 and installing water meters and collecting and using facility water balance data to improve water conservation and management.

ELECTRICAL

The EPAct of 2005 required that Federal buildings be electrically metered by October 1, 2012, with metering devices that provide data at least daily and that measure at least hourly consumption of electricity. In 2009, KSC completed a project that effectively metered all KSC GS facilities for electricity consumption. As an extension of the 2009 effort, GSDO Program committed $1.6 million toward metering the consumption of third-party customers. KSC has also installed BTU meters at the Utility Annex for users on its loop. No BTU meters are installed at the IACP yet. Metering will enable KSC to uniquely identify user consumption in circumstances where perhaps infrastructure is being shared, such as with central cooling and heating plants. One concern is the consumption by third parties where the space being occupied does not relate at a 1:1 ratio to the metering that is in place. In many cases when the partnership agreement only includes part of an existing facility, the cost of metering has been too high to justify installing submeters for this new, and often temporary, user. In turn, the ability to quantify such electricity usage has been a challenge.

In FY 2015, KSC worked with FPL to create an electric metering plan that addresses the remaining facilities that do not have unique metering needs and the facilities (such as the O&C Building) that need submetering because of a shared space with a reimbursable entity. Alternative options, such as meters with radio frequency capability, are also addressed as a means to reduce the cost to add metering to remote facilities and installations.

NATURAL GAS

KSC has meters for all natural gas consuming facilities on Center which meet EISA of 2007 Section 434. These meters are installed, maintained, and read by KSC's local natural gas utility company, Southern Company.

WATER

Because potable water in Florida is very inexpensive, it has been challenging to justify the costs of installing water meters in many areas across KSC. The Center does have meters on all large consumers and most facilities occupied by our reimbursable partners. Where meters are lacking and individual billing is required, consumption is estimated using a methodology that is agreed upon by KSC and the billed partner until a meter does get installed. New water meters are added as often as funding becomes available and generally when new reimbursable partners come on site. Water meters, if installed and integrated into AUDRIS, could help identify water leaks and major breaks within the system.

DATA CENTERS

The new Kennedy Data Center (KDC) became operational January 2016 and was designed to be fully metered to meet stringent Office of Management and Budget Power Usage Effectiveness (PUE) requirements. The KDC will be the only data center at KSC by mid-FY 2017 and is forecasted to have all metering in place by the end of FY 2016. When all metering is complete, the PUE measurements will be very accurate and a PUE of 1.5 is expected by FY 2018.

RESOURCES

NASA is mission-oriented and must balance mission requirements with the institutional support needed to accomplish the missions. Working within a budget restricted environment, it is important that KSC pursues economically and environmentally sustainable paths. The Energy and Water Management Plan provides guidance for a utility infrastructure that assists in achieving these objectives.

To become financially and environmentally sustainable, KSC needs innovative methods to conserve funding. Investing in energy efficiency measures is one way to do this. The ROI for such projects have been exceptional to date. Various financial paths have been employed including CECR funding, direct appropriations from the CMO budget, performance contracting, direct CoF appropriations, and utility rebates. KSC's Energy and Water Manager is working to implement a reinvestment plan focused on energy projects. A successful energy reinvestment plan will include:

- Financing methods
- Payback period requirement
- Savings and cost calculation guidelines
- Budget restraints
- Guidance for completing energy projects

With the many approaches that KSC can employ to get projects funded, it will be important to ensure key employees are not just aware of these opportunities but that they are trained with the best strategies for each category.

CONSTRUCTION AND ENVIRONMENTAL COMPLIANCE AND RESTORATION FUNDING

In recent years, KSC has received CECR funding for several projects to be implemented through FY 2016. Some of these recent projects are:

- IACP TES Project – $5.8 million
- Up to 2 MW Solar Farm Expansion – $6.8 million
- LED Lighting Retrofit – $2.4 million

With an abundance of energy and water conservation projects already identified across the Center, KSC welcomes the opportunity to continue competing with other NASA centers for this type of funding. A key strategy is to build a diversified portfolio of projects that address energy efficiency, water efficiency, renewable and clean energy, metering, and resiliency projects.

CENTER MANAGEMENT AND OPERATIONS FUNDING

The Center may retain energy and water savings in accordance with the NECPA for energy efficiency projects.

> *42 U.S.C. 8256(e) RETENTION OF ENERGY AND WATER SAVINGS - An agency may retain any funds appropriated to that agency for energy expenditures, water expenditures, or wastewater treatment expenditures, at buildings subject to the requirements of section 8253(a) and (b) of this title, that are not made because of energy savings or water savings. Except as otherwise provided by law, such funds may be used only for energy efficiency, water conservation, or unconventional and renewable energy resources projects. Such projects shall be subject to the requirements of section 3307 of title 40.*

Typically, energy and water conservation projects yield O&M savings, so it is imperative to account for life cycle costs to ensure projects are optimally triaged. The EUL program was recently transferred to the KSC

Energy and Water Program at KSC and provides a modest funding source that can be used for energy and water saving projects.

PERFORMANCE CONTRACTING

The primary KSC alternative financing method has traditionally been the UESC mechanism. Since 1998, numerous UESC projects improving KSC's energy and water efficiency have been completed. Many were successful in lowering utility costs with a financial payback of less than eight years. The majority of the projects were completed with FPL, that started its first UESC project with KSC in 2012. Table 7 provides a list of the utility performance contracts on Center, respective project value, year initially contracted, and the corresponding contractor.

Project Name	Project Value	Year	UESC
Lighting Upgrades – Various Facilities	$460,509	1998	FPL
Lighting Upgrades – Various Facilities	$68,285	1998	FPL
C5 Emergency Power Plant	$6,838,707	1998	FPL
TES Feasibility Study	$15,000	1999	FPL
LES Lighting	$26,971	2000	FPL
Communications Distribution and Switching Center Load Control	$4,500	2000	FPL
Shuttle Area Phase 1 – HVAC, Lighting Upgrades, and Compressed Air Upgrades	$3,177,532	2001	FPL
Shuttle Area Phase 2 – Upgrade to HVAC, Boilers, Lighting and Load Shedding Equipment	$3,696,068	2005	FPL
Modular Boiler Project	$4,894,546	2006	FPL
Mechanical Upgrades	$2,689,597	2012	FPL
Lighting Upgrades – Various Facilities	$776,000	2012	Southern Company
Lighting Upgrades – Various Facilities	$704,000	2013	FPL

Table 7 - Utility Performance Contracts

The Center will continue to pursue alternative financing through UESCs. As the above table shows, one of the largest UESC projects included decentralizing portions of the Central Heat Plant (modular boiler project). The Center found that even insulated piping exhibited substantial heat losses. Eliminating transmission lines and positioning modular boilers closer to their point of use has helped alleviate the issue. Overall, these projects in combination have provided substantial energy and cost savings.

OTHER FUNDING

The Center has benefited through direct appropriations for CoF projects too. A large, multiyear water conservation project was just completed in FY 2015. Phases 3 and 4 of the KSC Water and Wastewater Revitalization Project resulted in significant water savings, environmental benefits, and continued critical support of crewed and uncrewed launches at KSC. The Center's systems were refurbished and replaced to improve overall water quality, reduce overall water usage, extend infrastructure life, and replace asbestos cement piping.

Water system improvements involved replacing approximately 200,000 linear feet of water mains. Abatement and removal of 46,000 feet of asbestos cement piping were included, as well as the demolition of existing elevated storage tanks and replacement with new ground storage tanks and the construction of W-5, a new water booster station constructed to meet high demands of the Launch Complex 39 launch pads in support of manned and unmanned launches.

Wastewater improvements included the design of approximately 22,000 linear feet of gravity and pressure sewers. Fifty-nine lift stations were designed, rehabilitated, or upgraded to include electrical upgrades, all of which were designed for connection via new supervisory control and data acquisition components to the Kennedy Complex Control System (KCCS) for monitoring. From 2011 to 2015, when the project was completed, more than 262 million gallons of water were saved. The project cost approximately $11 million.

The President's FY 2017 budget proposal to Congress includes approximately another $11 million for Phases 5 and 6 of this same revitalization effort.

The TES project mentioned above provided KSC with a $1.5 million utility rebate. KSC retained half of the total rebate amount and half was sent to the U.S. Treasury. The Energy and Water Manager's intent is to reinvest 100 percent of it into new ECMs, pending approval of KSC management.

In FY 2015, the Center received $800 thousand from the Agency for an EUL project that would upgrade the HVAC system in building M7-0505.

Occasionally, one of the NASA programs located at KSC will fund conservation projects. For example, from FY 2013 to FY 2017, GSDO Program funding paid for miscellaneous mechanical and lighting upgrades across KSC that, when complete, will total $4.6 million.

STAFFING

Both civil service and contractor personnel support the KSC Energy and Water Management Program in meeting the goals of EO 13693. Full-time and part-time civil servants represent a variety of disciplines, including the Environmental Management Branch, O&M functions, CoF offices, and the Office of the Chief Financial Officer. The civil service cost numbers below represent a fully burdened composite rate based on current staffing support.

Contractor personnel include approximately 4.5 WYEs supporting the Center's energy and water management objectives as they relate to EO 13693. This WYE number represents only an approximation because in FY 2016 the contractor performing the work had a firm-fixed-price contract; support was not tracked by WYE but by output. Contractor costs below reflect a composite rate and a standard 3 percent escalation expected for each subsequent year. Contractor staffing seems to be adequate as of this writing.

The Center does not anticipate any substantial changes to these civil servant and contractor labor numbers. The following tables show current staffing levels, costs, and projections through FY 2025.

Current Civil Servant Staffing			
Year	# of FTEs	$/Hr	Cost
2016	5.3	$ 62.84	$ 692,748
2017	5.3	$ 64.73	$ 713,584
2018	5.3	$ 66.70	$ 735,301
2019	5.3	$ 68.74	$ 757,790
2020	5.3	$ 70.84	$ 780,940
2021	5.3	$ 73.01	$ 804,862
2022	5.3	$ 75.24	$ 829,446
2023	5.3	$ 77.54	$ 854,801
2024	5.3	$ 79.91	$ 880,928
2025	5.3	$ 82.34	$ 907,716
Total			$ 7,958,115

Table 8: Civil Service Support

Current Contract Support	
Year	Cost in Dollars
2016	$ 544,500
2017	$ 560,835
2018	$ 577,660
2019	$ 594,990
2020	$ 612,840
2021	$ 631,225
2022	$ 650,161
2023	$ 669,666
2024	$ 689,756
2025	$ 710,449
Total	$ 6,242,081

Table 9: Contractor Support

OTHER RESOURCES

There are several other resources that KSC may pursue. Federal grants are currently being reviewed to determine the eligibility and applicability to KSC projects in need of funding. Due to the limited timeframe during which a particular grant might be available, the Center has begun to more closely watch for these opportunities.

Apart from grants, another candidate resource is an ESPC called ENABLE (not an acronym). ENABLE is intended to provide a standardized and streamlined procurement process for Federal projects that have an estimated cost of up to $5 million. To be eligible, projects must install targeted ECMs in six months or less. While there are no specific facility size restrictions, an ESPC ENABLE is well-suited to meet the needs of many Federal facilities with less than 200,000 SF of space.

Additional CMO program support comes in the form of low-cost/no-cost ECMs such as changes to maintenance procedures and facility setpoint changes. The Center also has technical teams organized by discipline that conduct an independent review of conservation measures that come from facility condition assessments. Their labor is paid directly from the CMO budget.

UTILITY CONTRACTS AND RATES

Natural gas is a commodity that KSC procures under the DLA energy provision. DLA compares the commodity cost if purchased through the local gas utility, FCG, and others to determine the best option for KSC. The commodity is market-priced on a monthly basis via a publication entitled *Inside Federal*

Energy Regulatory Commission along with an adjustment factor based on a competitive pricing component. The Center has benefited from participation in the DLA Natural Gas Program. Figure 17, below, illustrates the savings per decatherm over time.

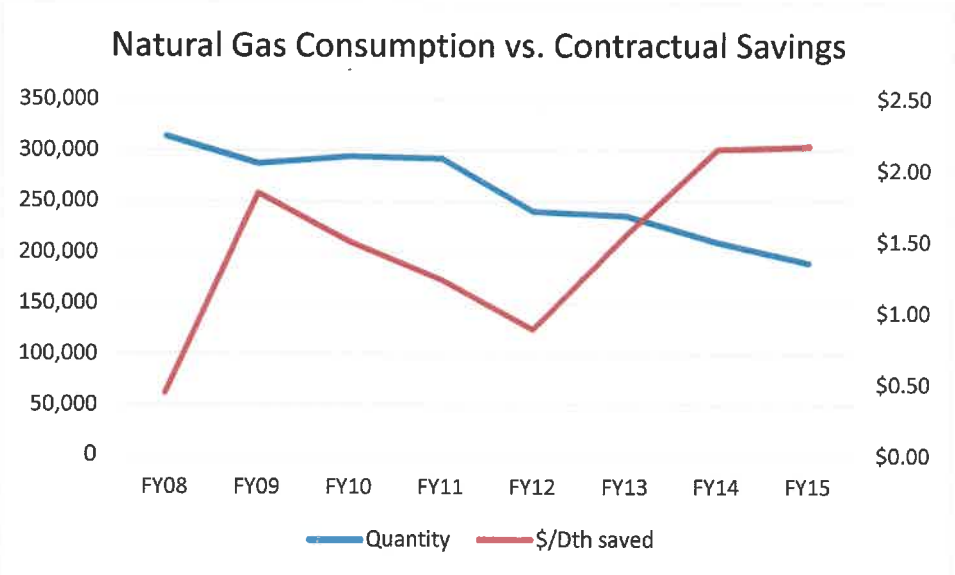


Figure 17: Natural Gas Consumption in Comparison to the Contractual Savings Through DLA

Charges for natural gas are based on tariffs per meter (as opposed to a single charge to the Center). The applicable rate is assigned to each meter based on the volume that is passed through that meter annually. The tariffs themselves change every year and can be seen below in Figure 18. Each program budgets for natural gas in its operating plan and through the PPBE process, using forecasted consumption and predicted rates. The Contracting Officer's Representative monitors natural gas prices in case an opportunity arises to purchase when prices are low. The corresponding finance department budgets for out-years based on historical records and dialogue with the commodity provider on any expected changes in cost.

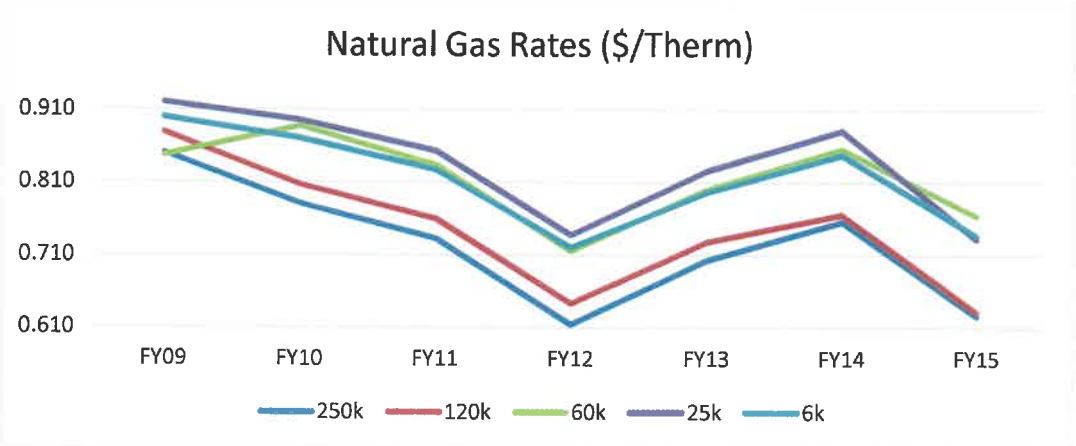


Figure 18: Natural Gas Actuals per Tariff (including all fees/charges)

Water and electricity are sourced solely through the local utilities that service KSC. Rates are regulated through the FPSC. In the first quarter of Calendar Year (CY) 2016, FPL informed KSC that its electric bill would decrease by 9.48 percent (approximately $1.145 million) in 2016, but could increase by 43 percent over the next 4 years. The FPSC recently approved a 17 percent rate increase to be phased in from FY 2017 through FY 2020.

The current utility contracts and their periods of performance are listed below:

Interconn Gas (SPE600-17-D-7511): Period of Performance: 2 years
Start: 6/01/2017
End: 5/31/2019

Southern Gas (NNK13OR30T): Period of Performance: 5 years with 2 option periods
Base Period: 10/01/2013-9/30/2015
Option Period 1: 10/1/2015-9/30/2017
Option Period 2: 10/1/2017-9/30/2018

FPL (NNK14OR10T): Period of Performance: 5 years with 2 option periods
Base Period: 5/01/2014 – 9/30/2015
Option Period 1: 10/1/2015–9/30/2017
Option Period 2: 10/1/2017–4/30/2019

City Of Cocoa (water) (Accounting Voucher 11014): Period of Performance:
Start: 10/01/2010
There is no expiration for Accounting Voucher contracts.

SUSTAINABLE ACQUISITION AND PROCUREMENT

KSC's process ensures that requirements to purchase ENERGY STAR®, FEMP-designated, and WaterSense® products are in all KSC contracts and are considered during all acquisitions.

The Center is currently in the process of changing NF 1707, Section 2, to add a KSC-specific subform. This subform requires purchase requestors to review Federal environmental procurement options and document if they apply to the procurement, if they will be met, or if a waiver is needed. The waiver approval process will require approval from the Environmental Management Branch.

FACILITIES

LEED® BUILDINGS

The Center maintains seven LEED® rated buildings with three other buildings awaiting certification.

NASA LEED® Rated Sustainable Buildings								
Facility No.	Facility Name	LEED Rating System	Size (Certified GSF)	LEED® Rating	Certification Date	Designed Annual Energy Use (MMBTU)	FY 2014 Actual Annual Energy Use (MMBTU)	FY 2015 Actual Annual Energy Use (MMBTU)
M6-0490	Life Support Facility	NC	22,120	Silver	4/29/2009		2,273	2,536
K7-0418	Propellants North Admin. Bldg.	NC	8930	Platinum	8/24/2011		175	263
K6-1446K	Electrical Maintenance Facility	NC	19,096	Gold	10/26/2011		684	1081
K7-0559	Ordnance Operations Facility	NC	3,685	Gold	3/28/2012		68	74
73019	Fuel Storage Area 1	NC	5825	Gold	9/13/2012		343	327
M7-0355	O&C Building	CI	260,013	Silver	6/6/2014		69,260	68,370
M7-0411	SSPF Science Annex	NC	6,000	Silver	2/6/2015		699	2,606
K6-1249	OSB II	EB	216,339	-	In work		11,736	13,362
-	Central Campus, Phase 1	NC	189,480	-	In work	11813.95	N/A	N/A
M6-0547	KDC	NC	23,217	Silver	8/29/16		N/A	N/A

Table 10: LEED Facilities

KSC evaluates all new construction and rehabilitation projects using the LEED® Green Building rating system. All new construction and major building renovation projects planned for award after October 1, 2005, shall meet the minimum LEED Silver rating (NPR 8820.2G). This requirement is included in KSC CoF statements of work issued to architecture and engineering firms.

From an O&M perspective, KSC invests efforts into LEED Commercial Interior and Existing Building (EB) projects, such as the O&C Building and the OSB II, respectively. The O&C project involved a gut and renovation of the entire north wing. The OSB II upgrades will result in the Center's first certified LEED EB and are expected to play a significant role in guiding future LEED EB decisions.

The Center conducts ongoing commissioning of all LEED buildings, comparing design criteria with actual performance. Anecdotal evidence from a variety of systems personnel indicates a good correlation in most cases between expectations and actual performance. Examples of utility data showing design criteria versus actuals will be included in later revisions of this document.

One notable exception where building performance was not meeting expectations pertained to the Propellants North Building. Several factors were at play, including problems with HVAC controls and metering discrepancies between electricity production from facility solar panels and electricity consumption at the facility. There was also an inverter fuse issue that went undetected for several months. Eventually each of these problems was resolved and building performance stabilized.

LEED certification of the OSB II has become a high priority. Challenges associated with this building include lighting control problems and issues pertaining to HVAC controls. An LED upgrade and lighting controls upgrade have been funded and are expected to resolve the lighting issue and improve building energy performance.

In parallel with LEED EB efforts, EO 13693 guiding principles are being investigated. The guiding principles have five high-level objectives for design, construction, and high performance and sustainable building O&M.

GUIDING PRINCIPLES

EO 13693 revised the guiding principles of previous EOs for both new and existing Federal buildings. The revised guiding principles for Federal Leadership in High Performance and Sustainable Buildings for Sustainable New Construction and Major Renovations include:

- Employ integrated design principles.
- Optimize energy performance.
- Protect and conserve water.
- Maximize indoor environmental quality.

- Reduce environmental impact of materials.
- Assess and consider climate change risks.

The revised guiding principles for Sustainable EB include:

- Employ integrated assessment, operation, and management principles.
- Optimize energy performance.
- Protect and conserve water.
- Enhance indoor environmental quality.
- Reduce environmental impact of purchases and waste materials.
- Assess and consider climate change risks.

An alternative approach to maintaining sustainable buildings is implementing the guiding principles described in EO 13693. The guiding principles are a series of facility performance requirements with the potential to replace LEED New Construction (NC) and LEED EB as a means to ensure sustainable infrastructure. It is important to analyze further the LEED NC and LEED EB benefits compared to the recently introduced guiding principles to ensure optimal decisions. NASA Headquarters confirmed that the DOE compliance tracking system shall be used to document compliance with the guiding principles.

EO 13693 requires that, beginning in FY 2020 and thereafter, all new construction of Federal buildings greater than 5,000 GSF that enters the planning process be designed to achieve energy net-zero and, where feasible, water or waste net-zero by FY 2030. In addition, agencies are required to identify a percentage of their existing buildings above 5,000 GSF intended to be energy, waste, or water net-zero buildings by FY 2025 and implementing actions that will allow those buildings to meet that target. EO 13693 also requires agencies to identify, beginning in June of 2016, a percentage of at least 15 percent, by number or total square footage, of the its EB above 5,000 GSF that will, by FY 2025, comply with the revised guiding principles, and make annual progress toward 100 percent compliance with the guiding principles for its building inventory.

Due to these requirements, KSC will diligently pursue compliance with NC and EB guiding principles by 2025. While relatively new to KSC, the revised guiding principles are an excellent opportunity to leverage O&M strategies for financial benefit and good environmental stewardship.

COMPREHENSIVE EVALUATIONS

LONG-TERM GOALS

The Center is performing annual FCEs on 25 percent of its GS facilities with the intent of conducting FCEs on 100 percent of its facilities every 4 years. NASA Headquarters has defined covered facilities as GS facilities. Comprehensive evaluations identify ECMs and WCMs. While FCEs provide no direct ROI, they are a great resource for future planning because they identify all existing facility deficiencies.

The FCEs consist of a combination of facility condition assessments and energy audits. Onsite contractors perform the FCEs. Energy audits are classified by increasing level of effort as level one, level two, and level three ASHRAE audits. Facility energy intensity and expected future use help determine facility selection for auditing purposes and also help determine the appropriate level of audit effort. In addition to audits performed by an onsite contractor, utility providers can perform facility audits at no upfront cost. KSC is confident the 25 percent requirement will be met through the onsite contractor. In addition, the Center intends to use utility partners to provide additional review of select facilities where anticipated ECMs and WCMs could result in a performance contract.

CURRENT PROGRESS

During an audit, the major energy consumers of a building are reviewed and evaluated. Particular review elements include the building envelope, light fixtures, lighting controls, the HVAC system, and the HVAC controls. Subsequently, a report is developed providing a building description, energy consumption elements, and potential energy conservation projects. The energy conservation projects include a preliminary cost estimate and calculated energy savings.

A section within each report is dedicated to water, including a description of facility water components and water efficiency opportunities. The water efficiency opportunities contain a preliminary cost estimate and calculated water savings as well. A record of all ECMs and WCMs and subsequent projects that become funded is stored in AUDRIS.

The current list of ECMs and WCMs is found in Appendix C. The current audit schedule of facilities to meet the 25 percent goal is found in Appendix B.

REQUIRED ACTIONS

AUDRIS maintains a list of ECMs. When an AUDRIS user identifies an ECM for future funding, a strategic team within the O&M community, called the System Health and Readiness Program (SHARP), investigates the ECM for further validation and provides a recommendation. The SHARP team also reviews and modifies ECMs as necessary to ensure a proposed solution is consistent with KSC's O&M goals. Based on the SHARP team's evaluation, an ECM is finalized and processed through an O&M board for approval. The ECMs are selected and prioritized based on mission necessity, probability of imminent failure, and lowest

ROI. Occasionally, projects are a result of bundling multiple ECMs and/or WCMs to increase probability for an acceptable payback.

In FY 2016 approximately 0.4 WYEs were dedicated to energy audits and 0.1 WYEs were allocated for water. The WYE numbers represent only an approximation because the contractor performing the work had a firm-fixed-price contract. Contractor staffing for FCEs seems to be adequate as of this writing.

EXPECTED OUTCOMES

Expected outcomes of the annual audits include a more energy- and water-efficient infrastructure. As previously described, ECMs and WCMs are the primary means to achieve greater efficiencies by low-cost commissioning efforts. For ECMs not funded immediately, the Energy and Water Management Team continues to propose projects to KSC-hosted programs (e.g., the Launch Services Program) for available funding as a means to reduce future financial burdens. Programs are also reminded that UESCs are an available option for financing projects. KSC expects, for the next ten years, to be compliant with comprehensive energy and water evaluation requirements.

ENERGY AND WATER SECURITY, RELIABILITY, AND RESILIENCE

Energy and water security, reliability, and resilience are a subject of much discussion within key disciplines at KSC. The Federal Government and NASA have prioritized these efforts in policy, including the EPAct of 2005, EISA of 2007, EO 13693, and NPR 8570.1A. In general, the Center recognizes that energy conservation, water conservation, and renewable energy efforts advance energy and water security and resilience. In addition, cybersecurity is increasingly critical as systems, including EMCS and other Supervisory Control and Data Acquisition Systems, become targets of cyberattacks.

LONG-TERM GOALS

The current future of global energy supply is uncertain in regard to both its availability and cost. It is important that NASA reduce its exposure to the uncertain energy future by constantly evaluating how to reduce energy and water consumption, increase production of renewable energy, and implement sustainable solutions when determined feasible.

CURRENT PROGRESS

Title 10 CFR Part 436, Subpart F, Section 436.105, requires that Federal agencies have an Emergency Energy and Water Conservation Plan. NPR 8570.1, Section 3.3.4.c.10, requires that, as part of its Energy Management Program, each Center have this plan in place. This document is intended to support the NASA COOP Procedural Requirements in accordance with NPR 1040.1.

EMERGENCY ENERGY SECURITY AND CONSERVATION PLAN

KSC has a draft version of the Emergency Energy Security and Conservation Plan (EESCP) that is now being reviewed and will meet the requirements of 10 CFR 436.105 and NPR 8570.1A.

ENERGY AND WATER SYSTEM INFRASTRUCTURE

KSC continually assesses and upgrades (as funding permits) its existing energy and water system infrastructure to increase reliability and resiliency. In addition to the EESCP document referenced above, KSC has made extensive efforts to ensure resiliency and has documented its policies and procedures in the following documents:

- KNPR 8715.2: Comprehensive Emergency Management Plan (CEMP)
- KDP-P-3701: Continuity of Operation Planning (COOP) Emergency Funding
- KDP-KSC-P-3012: Loss of Utilities
- KNPR 8500.1: Kennedy Space Center Environmental Requirements
- KDP-KSC-P-3006: Kennedy Space Center Tropical Storm and Hurricane Preparation
- KDP-KSC-P-3007: Damage Assessment and Recovery

BACKUP AND UNINTERRUPTIBLE POWER SYSTEMS

KSC owns and operates a number of backup generators and uninterruptible power systems (UPS) to ensure critical mission and facility operations are able to continue during and after a constraining event, if necessary. In addition to the renewable/alternative energy components mentioned, the list of backup generators and UPS is extensive. See Appendix D.

CYBERSECURITY

The energy and water teams rely on and work with NASA Information Technology (IT) Security for all cybersecurity items. The IT team ensures compliance on all IT devices by enforcing policies which include, but are not limited to, NPR 2810.1A and NIST SP 800-82. A list of all Industrial Control Systems is provided in Appendix E.

In the event of a cyber threat, the NASA Security Operations Center (SOC) and the KSC Incident Response Team (IRT) will respond accordingly. In addition, the SOC and KSC both aggressively issue critical software patch actions to ensure cyber vulnerabilities of systems `are mitigated as soon as possible. The SOC Threat Vulnerability Analysis team also monitors emerging threats, alerting NASA IRTs of any potential attacks. The NASA IRTs hold weekly meetings and have an online "chat room" capability to quickly disseminate and exchange information.

To ensure KSC is one step ahead, the Office of the Chief Information Officer has multiple ongoing activities to improve overall security, including Industrial Control Systems. This effort is aided by the Agency IT Security Awareness and Training Center, which is responsible for IT security awareness training for the Agency.

REQUIRED ACTIONS

As Center objectives change and a wider variety of users partner with KSC for Center resources, the Center must continue to evolve its utility infrastructure. The Center will do this by keeping the infrastructure not only energy efficient, reliable, and secure now but also by anticipating and addressing future challenges in a timely manner. Technological advances and a Center-wide focus on reducing energy demand will play a pivotal role in this effort, as will pursuing renewable energy solutions. More work is needed to harden present assets from environmental and external threats. The Center could also improve its resilience by adding a wider variety of energy sources (e.g., CHP, fuel cells, biomass conversion, wind, tides, and ocean currents) in substantial quantities to its portfolio.

RISKS

A breach of KSC's computer networks is always possible, whether through a malicious external attack or through employee carelessness. Much preventive action has been taken to manage both external and internal threats. The Center's IT group regularly and automatically installs software upgrades on all KSC computers connected to its network and maintains rigorous control over allowing a non-KSC computer to connect inside KSC's firewall. The KSC workforce is required to receive regular training on cybersecurity risks and the training is updated as risks evolve.

EXPECTED OUTCOMES

The Center expects to remain vigilant in improving energy and water security, reliability, resilience, and cybersecurity. Center personnel remain vigilant to stay informed on threats within their areas of responsibility.

KSC is particularly reliant on backup generators for power. Although the generators have proven their worth on many occasions, there are more efficient and less cumbersome ways of addressing unplanned power outages. One example is through the incorporation of CHP systems into KSC's infrastructure. Whether in the form of small microturbines or much larger industrial-scale systems, Center personnel are beginning to take a closer look at CHP technologies. It is hoped that suitable and economic applications will be identified and installed in the near future. So far, no KSC facilities have been identified as good candidates for CHP applications.

APPENDIX A: ACRONYMS

45 SW	45th Space Wing
AHU	Air Handler Unit
ASHRAE	American Society of Heating, Air Conditioning, and Engineering
AUDRIS	Automated Utility Database Reporting and Information System
BAS	Building Automation System
BFF	Booster Fabrication Facility
BTU	British Thermal Unit
BTU/GSF	British Thermal Unit per Gross Square Foot
CCAFS	Cape Canaveral Air Force Station
CD&SC	Communications Distribution and Switching Center
CECR	Construction and Environmental Compliance and Restoration
CEM	Certified Energy Manager
CFR	Code of Federal Regulation
CHP	Combined Heat and Power
CILC	Commercial Industrial Load Control
CoF	Construction of Facilities
CMO	Center Management and Operation
CY	Calendar Year
DACS	Data Acquisition System
DLA	Defense Logistics Agency
DOD	Department of Defense
DOE	Department of Energy
EB	Existing Building
ECM	Energy Conservation Measure
EESCP	Emergency Energy Security and Conservation Plan
ECPP	Energy Conservation Performance Plan
EISA	Energy Independence and Security Act
EMCS	Energy Management Control System
EO	Executive Order
EPAct	Energy Policy Act
ESPC	Energy Savings Performance Contract
EUL	Enhanced Use Lease
EWG	Energy Working Group
FCE	Facility Comprehensive Evaluation
FCG	Florida City Gas
FEMP	Federal Energy Management Program
FPL	Florida Power & Light
FPSC	Florida Public Service Commission
FTE	Full-time Equivalent
FWS	Fish and Wildlife Service

FY	Fiscal Year
GAL/GSF	Gallons per Gross Square Foot
GE	Goal Excluded
GS	Goal Subject
GSDO	Ground Systems Development and Operations
GSF	Gross Square Feet
HVAC	Heating, Ventilation, and Air Conditioning
IACP	Industrial Area Chiller Plant
ICS	Institutional Control Systems
IOZ	Industrial Operations Zone
IRT	Incident Response Team
ISC	Institutional Services Contract
IT	Information Technology
KCCS	Kennedy Complex Control System
KDC	Kennedy Data Center
KNPR	Kennedy NASA Procedural Requirement
KSC	Kennedy Space Center
kW	Kilowatt
LC-39	Launch Complex-39
LCC	Launch Control Center
LED	Light-Emitting Diodes
LEED®	Leadership in Energy and Environmental Design
LETF	Launch Equipment Test Facility
LES	Launch Equipment Shop
MMBTU	Million BTUs
MMBTU/GSF	Million BTUs per Gross Square Feet
MPPF	Multi-Payload Processing Facility
MW	Megawatt
MWh	Megawatt Hour
NASA	National Aeronautics and Space Administration
NECPA	National Energy Conservation Policy Act
NC	New Construction
NIST	National Institute of Standards and Technology
NPD	NASA Policy Directive
NPR	NASA Procedural Requirement
O&M	Operations and Maintenance
OHF	Occupational Health Facility
OPF	Orbiter Processing Facility
OSB	Operations Support Building
PHSF	Payload Hazardous Servicing Facility
PMP	Priority Management Plan
PPBE	Planning, Programming, Budgeting, and Execution

PUE	Power Usage Effectiveness
PV	Photovoltaic
RE	Reimbursable
RECs	Renewable Energy Certificates
RICE-NESHAP	National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines
ROI	Return on Investment
SA	Supply Air
SEMS	Sustainable Environmental Management System
SF	Square Feet
SGR	Self-Generated Renewable
SHARP	System Health and Readiness Program
SI	Spaceport Integration and Services
SOC	Security Operations Center
SP	Setpoint
SSPF	Space Station Processing Facility
TBD	To Be Determined
TES	Thermal Energy Storage
TOSC	Test, Operations, and Support Contract
TPSF	Thermal Protection System Facility
UESC	Utility Energy Service Contract
UPS	Uninterruptible Power Systems
U.S.	United States
U.S.C.	United States Code
VAB	Vehicle Assembly Building
VAV	Variable Air Volume
VFD	Variable Frequency Drives
WCM	Water Conservation Measure
WWG	Water Working Group
WYE	Work Year Equivalent

APPENDIX B: COMPREHENSIVE EVALUATION SCHEDULE

This list represents a plan for Facility Comprehensive Evaluations (FCEs) performed between April 2016 and April 2017. Goal Subject (GS) facilities on the list were chosen based on Gross Square Feet (GSF) and when they last had an FCE performed on them.

METERED AREA NUMBER	SQUARE FOOTAGE	Planned Audit	Planned FCA
60680	51,570	1	
66250	76,750	1	
66330	25,366	1	
J7-0689	30,000	1	
K6-1193	6,620		1
K6-1246	25,013	1	
K6-1247	51,124	1	
K6-1249	216,339	1	
K6-1696	62,279		1
K7-0468	11,337		1
M6-0490	22,120	1	
M6-0493	15,449	1	
M6-0688	21,701		1
M6-0698	35,868	1	
M6-0744	92,894		1
M6-0794	69,939	1	
M6-1671	34,101	1	
M7-0360	532,618	1	
M7-0505	109,654	1	
M7-0777	29,741	1	
M7-1354	18,913	1	
M7-1357	28,129	1	
TOTALS:		15*	5

**Note: M7-1354 and M7-1357 are in the same metered area and will therefore be counted as one complex.*

APPENDIX C: LIST OF ENERGY CONSERVATION MEASURES AND WATER CONSERVATION MEASURES FROM COMPREHENSIVE EVALUATIONS

The information represented in this table is dynamic and therefore reflects only project information at the time of query. The database is updated far more frequently than the table. Projects with an estimated payback time of more than ten years might never be funded and therefore are not listed here.

Facility No.	Facility Name	Project Description	Estimated Annual Cost Savings ($)	Estimated Cost Payback in Years
J6-2370	Fire Station #2	Low Bay Heating, Ventilation, Air Conditioning (HVAC) Operation Improvements	15,000	0
J6-2465	Flight Vehicle Support Building	HVAC Operation Improvements Reset Schedule and Reduce Duct Pressure	5,555	0
K6-0794	Thermal Protection System Facility (TPSF)	Lamp Wattage Reduction, Replace 32W lamps with Light-Emitting Diodes (LEDs)	3,836	9.65
K6-0794	TPSF	Occupancy Sensors	2,535	8.28
K6-0848	Vehicle Assembly Building (VAB)	Low Bays K, L, M, and N Air Conditioning (AC) Units AC-100, -101, -102, and -103: employ energy-saving control strategies to Supply Air (SA) Temperature Reset Setpoint (SP) Reset and Demand Controlled Ventilation	56,840	8.66
K6-0848	VAB	Replace AC-8A (Columbia Storage) (2 years remaining service life) with Variable Air Volume (VAV) unit with digital controls	12,040	7.8
K6-0900	Launch Control Center (LCC)	Update AC units AC-200, -201, -202, and -203 for energy-saving control strategies	146,428	2.95
K6-0900	LCC	LED Retrofit 4th floor Firing Rooms	16,593	9.52
K6-0900	LCC	Space Temperature SP Moderation – All Spaces	171,516	0
K6-0900	LCC	Replace 32W Fluorescent Lamps with 17.7W LEDs	98,841	9.29
K6-0947	Utility Annex	Replace three 50-inch Liquid Crystal Display (LCD) monitoring screens with 50-inch LED screen (assume simple replacement)	1,002	6.6

Facility No.	Facility Name	Project Description	Estimated Annual Cost Savings ($)	Estimated Cost Payback in Years
K6-1096	Operations Support Building (OSB) I	Demand Control Ventilation Sequence	6,288	6.87
K6-1096	OSB I	Replace T8 Fluorescent Lamps with LEDs in Office Areas (includes LED + HVAC + maintenance cost savings)	142,530	4.91
K6-1246	Utility Shops Facility	CO2-Based Demand Control Ventilation AHU-1 and -2	4,476	2.9
K6-1246	Utility Shops Facility	SA Temperature Reset (Zone Based) AHU-1	593	4.55
K6-1246	Utility Shops Facility	Reduce Off-Hours Power Consumption and AC by Turning Computers Off Overnight and Weekends	13,000	0
K6-1247	Launch Equipment Shop	Change High-Bay Light Fixtures to LED	17,928	8.64
K6-1249	OSB II	Lighting Upgrades	79,771	5.12
K6-1446K	Electrical Maintenance Facility	Recommissioning	3,331	6.87
K6-1547	Logistics Facility	Replace T8 Fluorescent Lamps with LEDs in Office Areas	61,000	4.5
L6-0146	Engineering and Admin Building	Cool Roof Installation	26,602	1.88
L6-0146	Engineering and Admin Building	Lighting and Occupancy Sensor Upgrades	5,093	6.92
L6-0247	Manufacturing Building (formerly Booster Fabrication Facility [BFF])	Ordnance Operation Correction	36,352	0
L6-0247	Manufacturing Building	Turn Off Cell AHUs if Not Active	33,475	0
L6-0247	Manufacturing Building	Install 13 Variable Frequency Drives (VFD) for AHUs	81,810	7.2
L6-0247	Manufacturing Building	Lighting Retrofit - Change Out All Fluorescent Lamps to LEDs With No Ballasts	56,234	10
M6-0138	Communications Distribution and	Update AHU-1A to True Multizone VAV	16,822	8.97

Facility No.	Facility Name	Project Description	Estimated Annual Cost Savings ($)	Estimated Cost Payback in Years
	Switching Center			
M6-0495	Dispensary (commonly called the Occupational Health Facility [OHF])	Lighting Retrofit Replace Fluorescent Lamps with LEDs and No Ballasts	10,969	8.1
M6-0495	Dispensary	Replace HVAC System in West Addition	98,784	7.6
M6-0791	Communications Maintenance and Storage	Change Out T8 28W Lamps With LEDs and No Ballasts	7,686	10.2
M7-0351	Auditorium and Training Building	Replace T-8 Lamps and Ballasts With LEDs (Includes LED + HVAC + maintenance cost savings)	29,800	5.8
M7-0355	Neil Armstrong Operations and Checkout Building (O&C)	Create a Program to Modulate Existing VFDs on SF-18, SF-19, and SF-20	69,484	0.1
M7-0355	O&C	Design and Install Building Automation System (BAS) System for Offline Labs; Design and Install Controllers and VFDs for 22 AHUs; Modernize the HVAC Operation Control Including a Weather Station and Controller Reset per Weather Conditions	168,815	8.3
M7-0360	Space Station Processing Facility (SSPF)	Reduce Lighting in Main Corridors on All Levels and All Areas by Removing 1 Lamp per Fixture	10,604	1.15
M7-0360	SSPF	Daylight Harvesting - Install Photosensors for Lighting Control in Order to Benefit More from Natural Lighting	2,986	3.19
M7-0360	SSPF	Reduce Hardware Area Cubic Feet per Minute - Reduce Air Circulation to 2 Changes per Hour and Introduce Conditioned Outdoor Air from AHU-12	13,223	1

Facility No.	Facility Name	Project Description	Estimated Annual Cost Savings ($)	Estimated Cost Payback in Years
M7-0360	SSPF	Tunnel - Reduce Air Circulation and Outside Air Flow	13,666	2.46
M7-0360	SSPF	Replace Inefficient Lighting with Efficient LED Lighting	231,529	5.42
M7-1104	Multi-Payload Processing Facility	AHUs and Building Automation System Upgrades	60,202	3.41
M7-1354	Payload Hazardous Servicing Facility (PHSF)	PHSF AHU Upgrades - Upgrade the Precooling Coils and Add VFDs to Supply Fans	235,153	1.02

APPENDIX D: LIST OF BACKUP GENERATORS

Description / Location Information		Engine Power Output Information		
Facility No.	Description	Startup Date	Displacement (liters/cylinder)	Nominal Kilowatt (kW) Rating
K6-1091	Launch Complex 39 (LC-39) Emergency Power Station/Generator #1	6-Apr-1999	4.3	2,000
K6-1091	LC-39 Emergency Power Station/Generator #2	6-Apr-1999	4.3	2,000
K6-1091	LC-39 Emergency Power Station/Generator #3	5-Apr-1999	4.3	2,000
K6-1091	LC-39 Emergency Power Station/Generator #4	5-Apr-1999	4.3	2,000
K6-1091	LC-39 Emergency Power Station/Generator #5	2-Apr-1999	4.3	2,000
K7-1203	Press Site Emergency Generator Building/Generator #1	2005	2.6	500
K7-1203	Press Site Emergency Generator Building/Generator #2	2005	2.6	500
M6-0139	Communications Distribution and Switching Center (CD&SC)/Generator Building Generator #1 East	1997	2.3	350
M6-0139	CD&SC Generator Building/Generator #2 Middle	1997	2.3	350
M6-0139	CD&SC Generator Building/Generator #3 West	1997	2.3	350
M7-0360	Space Station Processing Facility (SSPF)/Generator	1999	2.45	2,000
M7-0360	SSPF/Generator	10-May-1999	2.5	1,200
M7-0360	SSPF/Generator	1995	1.3	150
M7-1354	Payload Hazardous Servicing Facility/Generator	22-Nov-2010	2.7	1,000
E3-1133	Mid-Course Radar Facility/Generator	2006	2.8	800
J6-2370	Fire Station 2/Generator	5-Aug-2010	1.5	250
M6-0495D	Dispensary Emergency Generator Building/Generator	1993	1.8	205
M3-0147	Indian River Bridge Emergency Generator Building/Generator	18-Jun-1996	1.7	200
M7-0355	Neil Armstrong Operations and Checkout Building (O&C)/Generator	2005	1.4	150

Description / Location Information		Engine Power Output Information		
Facility No.	Description	Startup Date	Displacement (liters/cylinder)	Nominal Kilowatt (kW) Rating
M7-0355	O&C/Generator	2005	1.4	150
J6-1874	Visitor Complex Apollo/Saturn V, Support Building/Generator	1997	1.1	125
M6-0458	Visitor Complex, Commissary Building/Generator	2006	0.6	50
M6-0410	Visitor Complex, Administration Building	15-Jul-14	0.9	63
J5-1197	Shuttle Landing Facility Air Traffic Control Tower/Generator	2002	1.1	150
J6-0490	500 FT Weather Tower Equipment Building/Generator	2001	1.4	125
H2-1245	Jay Jay Bridge Generator Building/Generator	1992	1	100
M7-0531	Banana River Repeater Station/Generator	2005	1.1	64
M6-0493C	Industrial Area Support Building Emergency Generator Building/Generator	1994	1	60
E4-2414A	Haulover Canal Bridge Emergency Generator Building/Generator	1996	1	60
M6-0336	Electromagnetic Lab/Generator	1998	1	60
M6-0791	Communications Maintenance and Storage/Generator	1995	0.3	8
60674	Hangar AE/Generator	16-Jun-2011	3.7	1,000
60674	Hangar AE/Generator	16-Jun-2011	2.5	400
M6-0695	Fire Station 1/Generator	3-Sep-2013	1.1	107
M7-1104	Multi-Payload Processing Facility/Generator	TBD	2.3	750
M6-0547	Kennedy Data Center (KDC)/Generator	TBD	3.14	1,250
M6-0547	KDC/Generator	TBD	3.14	1,250
J7-1388	Industrial Water Pumping Station/Fire Engine #1	4-Nov-1997	4.3	795
J7-1388	Industrial Water Pumping Station/Fire Engine #2	4-Nov-1997	4.3	795
J7-1388	Industrial Water Pumping Station/Fire Engine #3	4-Nov-1997	4.3	795
J7-1388	Industrial Water Pumping Station/Fire Engine #4	4-Nov-1997	4.3	795
K6-0895	Orbiter Processing Facility (OPF) Pump House/Fire Engine #1	30-Sep-2005	4.3	770
K6-0895	OPF Pump House/Fire Engine #2	1983	5.2	477
K6-0895	OPF Pump House/Fire Engine #3	1983	5.2	477
M7-1362	FireX Pump Station/Fire Engine #1	1983	5.1	600

Description / Location Information		Engine Power Output Information		
Facility No.	Description	Startup Date	Displacement (liters/cylinder)	Nominal Kilowatt (kW) Rating
M7-1362	FireX Pump Station/Fire Engine #2	1983	5.1	600
M7-1362	FireX Pump Station/Fire Engine #3	30-Sep-2005	4.3	760
K6-0947	Utility Annex/Fire Engine #1	5/30/2017	2.25	392
K6-0947	Utility Annex/Fire Engine #2	5/30/2017	2.25	392
K6-0947	Utility Annex/Fire Engine #3	5/30/2017	2.25	392
K6-0947	Utility Annex/Fire Engine #4	5/30/2017	2.25	392
J6-2466	Reusable Launch Vehicle Hangar/Fire Engine #3	18-Nov-2008	1	140
J6-2466	Reusable Launch Vehicle Hangar/Fire Engine #4	18-Nov-2008	1	140
N6-0407	Grove Pump #3	< 9-Sep-2005 (Engine plate says engine was reconstructed 9-Sep-2005)	1	57
N6-0107	Grove Pump #5	2009	1.1	104
M6-1757	Grove Pump #6	<1960	0.9	92
M5-1586	Grove Pump #8	<1960	1.5	92
M5-1586A	Grove Pump #9	Apr-09	1	149
M6-0486	Grove Pump #10	<1960	1.47	82
M6-0166	Grove Pump #11	<1960	0.9	75
L5-0033	Pump House N13 "Grove Pump #13"	2000	1.8	131
M6-1627	Blast Building #2/Dust Collector #1	1992	1	41
M6-1627	Blast Building #2/Dust Collector #2	2009	0.75	60
M6-1627	Blast Building #2/Vacuum System	1993	1	114
TBD	Central Campus Headquarters Building	TBD	2.25	800
M7-1362	FireX Pump Station/Fire Engine #TBD	TBD	3.9	910

APPENDIX E: LIST OF INSTITUTIONAL CONTROL SYSTEMS

This table shows all institutional control systems (ICS) that control KSC energy or water facility systems.

Name of System	Manufacturer	Purpose of System	Name of IT Security System Point of Contact
Andover Controls Continuum #3389	Schneider Electric Andover Continuum	Monitors and controls HVAC, lighting, and energy consumption	Andover Controls Continuum
Engineering and Administration Building (formerly Booster Fabrication Facility [BFF]) #3128	Carrier i-Vu	Monitors and controls HVAC	BFF
Institutional Services Contract (ISC) Building Automation System (BAS) #3124	This security plan is not a system; it covers security controls that are applicable to each ICS: Kennedy Complex Control System (KCCS), Johnson Industrial Operations Zone (IOZ), BFF, and Andover	Not a system; master security plan that covers common controls to ICS	ISC BAS
ISC KCCS #3127	Schneider Electric Citect	Monitors and controls power and utilities	ISC KCCS
Johnson Controls IOZ Metasys #3390	Johnson Metasys	Monitors and controls HVAC	Johnson Controls IOZ Metasys
Kennedy Ground Control System (KGCS) #3459	Currently (2016): NASA Engineering and contractors with the Engineering Services Contract	The KGCS is the "heart" of monitoring and control for ground launch processing systems, which connects to the Spaceport Command and Control System. KGCS is used within the 25 ground support equipment subsystems located in the Mobile Launcher, Launch Complex 39B, the Vehicle Assembly Building, and the Multi-Payload Processing Facility (for crew module processing).	Robert VanArsdalen

Name of System	Manufacturer	Purpose of System	Name of IT Security System Point of Contact
Launch Equipment Test Facility Data Acquisition System (LETF-DACS) #3161	Currently (2016): NASA Engineering and contractors with the Engineering Services Contract	The LETF-DACS is a versatile test and development area that supports the entire spectrum of operational programs and accommodated full-scale qualification of Space Shuttle umbilical's and Time minus zero release mechanisms. It has been upgraded and refurbished to support NASA's Space Launch System Program, and is used to test a wide variety of large-scale hardware and ground support equipment components. Equipment at the facility can re-create liftoff and operational conditions to test component performance and can supply cryogenics, hydraulics, electrical, environmental control systems and other commodities to enable "test-as-you-fly."	Robert VanArsdalen
Test and Operations Support Contract (TOSC) Hazardous Operations Support Systems #3209	TOSC	Crawler – This is the crawler that supports transferring the Mobile Launch Platform and a vehicle between the launch pad and the Vehicle Assembly Building. There are General Electric programmable logic controllers (PLC) and Windows 7 in the system. Cranes – A mixture of General Electric and Allen Bradley PLCs, depending on the crane. They use Windows 7 and Windows 2008 to collect data and control the PLCs. They also have Windows 7 and Windows XP in place to load firmware in the PLCs. The laptops are single function devices that do not see a network; they are used exclusively for code changes to the PLCs. The Windows 7 laptops are new and replace XP boxes. KSC has struggled with the older GE PLCs code loading with Windows 7. We have recently purchased drivers from GE that will ease the transition. The laptops are turned on an average of two to three times a year. Ammonia Cart – Allen Bradley PLC, Cisco switch, and 1 HMI. The system runs in a portable cart to allow it to support several areas in the Space Station Processing Facility.	Randall Stalnaker

APPENDIX F: FACILITY FORECASTING TOOL